USING NEW OCEAN TECHNOLOGIES: PROMOTING EFFICIENT MARITIME TRANSPORTATION AND IMPROVING MARITIME DOMAIN AWARENESS AND RESPONSE CAPABILITY

(113–72)

HEARING

BEFORE THE

SUBCOMMITTEE ON
COAST GUARD AND MARITIME TRANSPORTATION

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

SECOND SESSION

MAY 21, 2014

Printed for the use of the
Committee on Transportation and Infrastructure

Available online at: http://www.gpo.gov/fdsys/browse/
committee.action?chamber=house&committee=transportation

U.S. GOVERNMENT PRINTING OFFICE

87–964 PDF WASHINGTON : 2014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

BILL SHUSTER, Pennsylvania, *Chairman*

DON YOUNG, Alaska
THOMAS E. PETRI, Wisconsin
HOWARD COBLE, North Carolina
JOHN J. DUNCAN, JR., Tennessee, *Vice Chair*
JOHN L. MICA, Florida
FRANK A. LoBIONDO, New Jersey
GARY G. MILLER, California
SAM GRAVES, Missouri
SHELLEY MOORE CAPITO, West Virginia
CANDICE S. MILLER, Michigan
DUNCAN HUNTER, California
ERIC A. "RICK" CRAWFORD, Arkansas
LOU BARLETTA, Pennsylvania
BLAKE FARENTHOLD, Texas
LARRY BUCSHON, Indiana
BOB GIBBS, Ohio
PATRICK MEEHAN, Pennsylvania
RICHARD L. HANNA, New York
DANIEL WEBSTER, Florida
STEVE SOUTHERLAND, II, Florida
JEFF DENHAM, California
REID J. RIBBLE, Wisconsin
THOMAS MASSIE, Kentucky
STEVE DAINES, Montana
TOM RICE, South Carolina
MARKWAYNE MULLIN, Oklahoma
ROGER WILLIAMS, Texas
MARK MEADOWS, North Carolina
SCOTT PERRY, Pennsylvania
RODNEY DAVIS, Illinois
MARK SANFORD, South Carolina
DAVID W. JOLLY, Florida

NICK J. RAHALL, II, West Virginia
PETER A. DeFAZIO, Oregon
ELEANOR HOLMES NORTON, District of Columbia
JERROLD NADLER, New York
CORRINE BROWN, Florida
EDDIE BERNICE JOHNSON, Texas
ELIJAH E. CUMMINGS, Maryland
RICK LARSEN, Washington
MICHAEL E. CAPUANO, Massachusetts
TIMOTHY H. BISHOP, New York
MICHAEL H. MICHAUD, Maine
GRACE F. NAPOLITANO, California
DANIEL LIPINSKI, Illinois
TIMOTHY J. WALZ, Minnesota
STEVE COHEN, Tennessee
ALBIO SIRES, New Jersey
DONNA F. EDWARDS, Maryland
JOHN GARAMENDI, California
ANDRÉ CARSON, Indiana
JANICE HAHN, California
RICHARD M. NOLAN, Minnesota
ANN KIRKPATRICK, Arizona
DINA TITUS, Nevada
SEAN PATRICK MALONEY, New York
ELIZABETH H. ESTY, Connecticut
LOIS FRANKEL, Florida
CHERI BUSTOS, Illinois

SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

DUNCAN HUNTER, California, *Chairman*

DON YOUNG, Alaska
HOWARD COBLE, North Carolina
FRANK A. LoBIONDO, New Jersey
PATRICK MEEHAN, Pennsylvania
STEVE SOUTHERLAND, II, Florida, *Vice Chair*
TOM RICE, South Carolina
MARK SANFORD, South Carolina
DAVID W. JOLLY, Florida
BILL SHUSTER, Pennsylvania *(Ex Officio)*

JOHN GARAMENDI, California
ELIJAH E. CUMMINGS, Maryland
RICK LARSEN, Washington
TIMOTHY H. BISHOP, New York
LOIS FRANKEL, Florida
CORRINE BROWN, Florida
JANICE HAHN, California
NICK J. RAHALL, II, West Virginia *(Ex Officio)*

CONTENTS

Committee on Transportation and Infrastructure
U.S. House of Representatives

Washington, DC 20515

Bill Shuster, Chairman — Christopher P. Bertram, Staff Director

Nick J. Rahall, II, Ranking Member — James H. Zoia, Democrat Staff Director

May 16, 2014

SUMMARY OF SUBJECT MATTER

TO:	Members, Subcommittee on Coast Guard and Maritime
FROM:	Staff, Subcommittee on Coast Guard and Maritime Transportation
RE:	Hearing on "Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"

PURPOSE

On May 21, 2014, at 9:30 a.m. in 2253 Rayburn House Office Building, the Subcommittee on Coast Guard and Maritime Transportation will hold a hearing to examine the proliferation of new or emerging ocean technologies, how such technologies could improve government performance, maritime commerce, and our understanding of the ocean environment and any impediments that limit or constrain the use of such technologies. The Subcommittee will hear from representatives of industry and academia.

BACKGROUND

Oceans cover 71 percent of the earth's surface and are home to an estimated 50 to 80 percent of all life on earth. However, less than five percent of the undersea world has been explored. Gaining a better understanding of the oceans and how its ecosystems work is important because the oceans play an integral role in our nation's economy, national defense, and our quality of life.

One of every six jobs in the United States is marine-related and over 40 percent of the U.S. Gross Domestic Product originates in coastal areas. Industries dependent on the ocean such as commercial fishing, marine transportation, offshore energy production, tourism, and recreation provided wages of over $107 billion to more than 2.8 million Americans in 2011. Finally, U.S. seaports transfer nearly $4 billion worth of goods in and out of our nation each day and move 95 percent of our nation's foreign trade each year.

The oceans provide the platform for our armed services to project forces throughout the world to ensure the security of our nation and that of our allies and protect the global supply chain that supports the U.S. economy. The Navy is capable of deploying nearly 290 ships worldwide to provide for our defense. U.S. servicemembers deployed overseas remain predominantly dependent on weapons and supplies transported by ocean-going vessels. For example, nearly 98 percent of all weapons and supplies delivered for U.S. and allied forces fighting in Iraq and Afghanistan were transported by vessel.

The oceans impact the daily life of Americans in several other ways:

- The oceans play a central role in the earth's climate and weather patterns.
- Ocean plants produce half of the world's oxygen and absorb one-third of carbon dioxide emissions.
- Approximately 30 percent of the oil and gas consumed in the world comes from offshore sources.
- According to U.N. Food and Agriculture Organization statistics, seafood supplies 16 percent of the world's protein consumed by humans
- Half of all communications between nations is carried on undersea cables.
- Marine biotechnologies provide the ingredients commonly used in household items such as soaps and cosmetics, but also produce medicines that help fight cancer, arthritis, Alzheimer's, heart disease, and other diseases.

The federal government is responsible for recording, understanding, monitoring, and protecting the oceans in the Exclusive Economic Zone that surrounds the United States and its territories out to 200 miles, and even in areas of the ocean beyond those littoral zones. Understanding and monitoring both the physical characteristics of these areas and how these areas are being used is vital to our national defense, the safety of maritime transportation, and to the conservation and management of the natural resources contained in these areas. For instance the Coast Guard must enforce all U.S. laws in these areas, as well as conduct search and rescue, icebreaking, coastal security, marine safety, marine resources protection, and oil spill response activities offshore. Unfortunately, manned operations offshore are expensive and potentially dangerous. In order to reduce costs and improve mission effectiveness, the Coast Guard and other federal agencies will likely become more reliant on ocean observation and maritime domain awareness (MDA) technologies that reduce costly time-on-station operations, provide operational flexibility, maximize the deployment of manned assets, and reduce annual and life time maintenance costs.

Ocean Technologies

Several private companies and academic institutions, often in collaboration with federal agencies, are working on developing ways to improve our understanding of the oceans and their ecosystems by inventing new, or making advances in existing, ocean observation and MDA technologies. Some of these technologies include:

Autonomous Vehicles

Autonomous underwater vehicles (AUV) and unmanned surface vessels (USV) have been used for the last several decades primarily by academic institutions for exploration and research purposes. Recently, however, several private companies have been developing larger and more advanced AUVs and USVs that could be used for commercial purposes such as, searching for offshore oil and mineral deposits, renewable energy production laying submarine cables, and salvage operations.

The Coast Guard and the National Oceanic and Atmospheric Administration (NOAA) are considering the use of autonomous vehicles to conduct missions such as patrolling fisheries; collecting current, tidal, and weather observation data; responding to oil spills; and detecting activities and collecting intelligence in the maritime domain.

Automatic Identification System

Automatic Identification System (AIS) is a Very High Frequency (VHF)-based, short-range communication system that provides a means for vessels to electronically exchange data, including identification, position, course, and speed, with other nearby vessels and shore-based AIS receivers. Depending on signal strength, weather, geography, and receiver capability, AIS signals can generally be received up to 50 miles away. The Coast Guard currently uses AIS to track the movements of commercial vessels greater than 300 gross tons operating in U.S. waters. Several private companies have developed enhanced AIS systems that leverage navigation data from satellite and other sources and integrate it into a single common operational picture that can be viewed on several platforms including smart phones.

High Frequency Radar

High Frequency Radar (HF) is used by NOAA and academic institutions to measure and track the speed and direction of surface currents in the ocean which have a direct impact on commercial shipping. NOAA and the Coast Guard use the data to help plot oil and hazardous material spills in the ocean, such as during the DEEPWATER HORIZON oil spill in 2010, as well as to improve search and rescue operations. Several private companies and academic institutions are working on advanced HF systems that can be coupled with other technologies to improve navigation and enhance the tracking of vessels in the maritime domain.

Ocean Sensors

Since the proliferation of satellites, a variety of sensors have been deployed to track currents, temperatures, and other physical characteristics of the world's ocean. NOAA uses free-floating sensors and other sensors attached to the seabed to help improve weather forecasts, detect tsunamis, determine the location and behavior of marine mammals and other marine life, and test water quality. Several private companies and academic institutions are working to improve the sensitivity of sensors, extend their operational life, enhance detection capability, and expand the use of data in the commercial sector.

Impediments

Regulations

The regulatory regimes of federal agencies often cannot keep up with advancements in technology. For instance, Coast Guard regulations currently do not contemplate the use of autonomous vehicles. Most UAVs and USVs are often too small or engaged in a non-commercial activity and do not meet the definition of a vessel used by the Coast Guard (see 1 U.S.C. 3). However, larger UAVs and USVs being developed today for commercial purposes may meet the definition of vessel and could be subject to Coast Guard regulations governing vessel construction, lighting, propulsion, and other standards.

Criteria for Ocean Technology

In 2011, the Ocean Studies Board of the National Academy of Sciences proposed criteria that could help prioritize federal agency investments for ocean technology infrastructure. These criteria include the affordability, efficiency, and longevity of the technology; and the ability of the technology to contribute to other missions or applications. These criteria may be useful to federal agencies in determining how to best meet their ocean technology needs.

WITNESS LIST

Thomas W. Altshuler, Ph.D.
Vice President & Group General Manager
Teledyne Marine Systems

Chuck Benton
CEO
Technology Systems, Inc.

Casey Moore
President
Sea-Bird Scientific

Dean Rosenberg
CEO
PortVision

Commander David M. Slayton
Research Fellow
Hoover Institution-Stanford University

Eric J. Terrill, Ph.D.
Director, Coastal Observing Research and Development Center
Marine Physical Laboratory- Scripps Institution of Oceanography

USING NEW OCEAN TECHNOLOGIES: PROMOTING EFFICIENT MARITIME TRANSPORTATION AND IMPROVING MARITIME DOMAIN AWARENESS AND RESPONSE CAPABILITY

WEDNESDAY, MAY 21, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:45 a.m. in Room 2253, Rayburn House Office Building, Hon. Duncan Hunter (Chairman of the subcommittee) presiding.

Mr. HUNTER. Good morning. I apologize for my tardiness. The subcommittee will come to order.

Today we are meeting to discuss using new ocean technologies to promote efficient maritime transportation and improve maritime domain awareness and response capability. This is a followup to our previous hearings regarding maritime domain awareness last July, and one earlier this year recommended by Ranking Member Garamendi, on the future of the Federal Government's navigation programs.

In addition, I held a roundtable in San Diego in February, and met with a variety of companies that are part of The Maritime Alliance. The Maritime Alliance represents over 1,400 companies in the San Diego area that produce $14 billion in direct sales and sustain 46,000 jobs from traditional maritime industries to high-tech companies; 19,000 of those jobs are high-technology jobs.

The Maritime Alliance has identified 14 distinct maritime technology clusters, such as ocean observation, ports and security, maritime robotics and large floating platforms. This is an area of the economy, particularly the high-technology maritime companies, that has been growing and provides cutting-edge products around the world. The companies involved in this sector are also significant exporters.

Today's hearing will highlight this sector of our economy, and we will learn how emerging technologies can be best used. We will also hear how we can improve the process for fielding new technologies in a more timely manner. Frankly, when it comes to that, the Coast Guard could use a lot of help, getting stuff probably within the first decade that it is created, and getting it into the Coast Guard.

In addition, we will hear testimony on large floating platforms and their possible applications, specifically in locations such as the Arctic. I believe the Arctic represents—and Mr. Garamendi does, as well—an opportunity for us to think outside the box on how we approach establishing a presence in the Arctic region, and what technologies can best be utilized in the Arctic.

With that, I yield to Ranking Member Garamendi.

Mr. GARAMENDI. Mr. Chairman, it's a pleasure working with you, and thank you very much for scheduling this hearing on new and emerging ocean technologies and their applications to advanced maritime transportation and ocean science research in the United States. This hearing is a perfect followup to our two previous technologically based hearings, and the meeting you had in southern California concerning the—and, respectively, the maritime domain awareness and the future of aids to navigation. I really am delighted with your interest in this area, I share that interest, and perhaps together we can advance this whole important arena.

From my perspective, however, two questions are the most pertinent to ask. First, is the United States aggressively maintaining its competitive edge in both basic and applied ocean research? And, second, is the United States still the global leader in the development of new innovations in maritime technologies?

The fact that I am even raising these questions should be alarming. Not too long ago, the United States was recognized as the uncontested world leader in scientific research and development, an edge that fueled the growth of our economy and led to unparalleled legacy of scientific achievement in the 20th century. Now the situation is quite different. Over the past 30 years, Federal funding for basic ocean science and applied research has been reduced, and is insufficient when compared with the level of funding invested in ocean science and engineering by our competitors from around the world.

Some critics have claimed, in fact, that we have entered a new world order in scientific research, including ocean science and engineering. In this new world order, the U.S. science will remain a leader. But other nations, especially China and India, will create an increasingly competitive environment, which will have serious ramifications on U.S. national security and economic strength further down the road.

What does this mean? Does this mean that this—what does this mean about this morning's hearing? First, we need to understand how these evolving circumstances are changing the scientific paradigm that has guided ocean science research in the United States for many decades.

We need to understand how the private sector and academic community are collaborating with Federal agencies, and we need to know how that collaboration can best be leveraged to advance the innovation in ocean science and engineering. The implications are huge for both our stature as a science leader, and our future as a global economic power.

Mr. Chairman, thank you so much for calling the hearing. I look forward to the testimony of the witnesses.

Mr. HUNTER. I thank the ranking member. I'm going to try to introduce everybody with the right names here. And if I do mess up,

just yell your last name out loud, the way it is supposed to be pronounced, please.

Dr. Thomas Altshuler—is that correct? OK. Vice president and group general manager of Teledyne Marine Systems; Mr. Chuck Benton, CEO of Technology Systems Inc.; Mr. Casey Moore, president of Sea-Bird Scientific; Mr. Dean Rosenberg, CEO of PortVision—Dean, very good to see you again; Commander David Slayton, research fellow with Stanford University's Hoover Institution; and Dr. Eric Terrill, director of the Coastal Observing Research and Development Center, Marine Physical Laboratory, the Scripps Institution of Oceanography. And there we have it.

So, Dr. Altshuler, you are recognized.

TESTIMONY OF THOMAS W. ALTSHULER, PH.D., VICE PRESIDENT AND GROUP GENERAL MANAGER, TELEDYNE MARINE SYSTEMS; CHARLES BENTON, CHIEF EXECUTIVE OFFICER, TECHNOLOGY SYSTEMS INC.; CASEY MOORE, PRESIDENT, SEA-BIRD SCIENTIFIC; DEAN ROSENBERG, CHIEF EXECUTIVE OFFICER, PORTVISION, A DIVISION OF AIRSIS INC.; DAVID M. SLAYTON, RESEARCH FELLOW, HOOVER INSTITUTION, STANFORD UNIVERSITY, AND COCHAIR AND EXECUTIVE DIRECTOR, ARCTIC SECURITY INITIATIVE; AND ERIC J. TERRILL, PH.D., DIRECTOR, COASTAL OBSERVING RESEARCH AND DEVELOPMENT CENTER, SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA, SAN DIEGO

Mr. ALTSHULER. Thank you, Mr. Chairman and distinguished members of the committee. I want to make a couple of brief remarks that I think will highlight the points that were just raised by Congressman Garamendi about the ocean.

So the ocean is one of the most exciting economic opportunities of the 21st century. The global reliance on ocean resources and the dependence on the marine environment will result in a continued growth in the so-called blue economy worldwide. The United States has a unique leadership position in many aspects of that economy right now. The U.S. is the single biggest market, and is a clear frontrunner in advance technology, and has established a role as a thought leader.

With all of these advantages, the immense growth potential of the marine market, the blue economy is likely to provide the U.S. businesses a strong return over the next decade, through both the domestic market and, more importantly, the international markets. This robust market will continue technology advancement that can be leveraged by everything from advanced ocean sciences to improving the efficiency and safety of Marine Transportation Systems.

As a business leader of one of the group of companies called Teledyne Marine Systems, I have had the privilege of working in this portion of the marine segment of Teledyne Technologies for almost 6 years. Teledyne recognizes the huge potential of this market over a decade ago, and has systematically grown its presence in the marine market.

Currently, Teledyne Marine is a growing group of 13 established, well-reputed undersea technology companies whose collective size

has expanded from $6 million in 2000 to over $600 million in 2013, with approximately half of the revenue resulting from international sales of our product. These companies have developed and introduced some of the most innovative technologies and products that have revolutionized the diverse marine markets, from offshore to inshore, and oceanographic to defense.

Teledyne Marine has achieved this growth through a combination of acquisitions, of technology-leading companies, and organic growth of those companies. This collective approach has resulted in strong, high-tech job growth, with direct and substantial impact on our local communities. Employing 2,000 people, our marine companies provide high-tech jobs nationwide, from Cape Cod, where I live, to San Diego, Seattle to Daytona Beach, and New Hampshire to the gulf coast.

Our product portfolio spans a wide range of capabilities, and that is one of the reasons that I think today will be very exciting for me. We provide undersea technologies, including unmanned vehicles, measurement systems, imaging and survey systems, underwater communication systems, and underwater connectors. The benefits gained with the associated high-performance, highly reliable products that we offer have ranged from new scientific discoveries to operational efficiencies in very harsh environments.

As Teledyne Marine looks to the future, we see exciting opportunity growths. Ours and our market peers' current technologies and technologies under development will revolutionize how we understand and leverage the ocean. In the oceanographic arena, which is core to our understanding of the marine environment, the United States has a clear leadership position.

Through programs such as the integrated oceanographic observing system, IOOS, led by NOAA, the regional partnerships between Federal and State governments, academic institutions, and the private sector, have resulted in a leap-ahead understanding of coastal marine environments. Its influences on fisheries and local economies in the United States, and even weather forecasting, is significant. These regional partnerships facilitated by IOOS are viewed worldwide as a highly successful example of how to effectively leverage human talent and resources for coastal marine studies, and have resulted in a growing export of marine technologies to the international community and driven advanced technology research and development. Other key Federal programs, such as the Ocean Observatories Initiative, have done the same.

As the oceanographic market grows, so does the defense and security in offshore arenas. Both fund the development and exploitation of corporate internal research and development will ensure that companies like Teledyne Marine and our peers can provide the most advanced technology into the worldwide blue economy. With the existing and emerging technologies, both the domestic and international markets will provide long-term manufacturing job growth for our U.S.-based businesses.

As we compete with foreign-developed technology, our technology advantage can be short-lived, and that is a big risk. What is needed is to facilitate export of our product to the key—is a key to sustaining positive economic impact for this blue economy in the

United States, and will provide affordable technology for broad marine applications throughout the United States.

Overall, because of the partnership across Federal and State governments, academic and nonprofit organizations, the blue economy is an outstanding opportunity for the U.S.

Mr. GARAMENDI. Ended right at 5 minutes.

Mr. HUNTER. Very good. Thank you.

Mr. Benton?

Mr. BENTON. Chairman Hunter and distinguished members of the committee, thank you for the opportunity to appear before you to testify on the subject of small vessel safety and security at this important hearing. I appreciate and welcome the committee's continued focus on this subject.

Vessel tracking enables collision avoidance, makes more efficient use of our waterways possible, and enhances maritime security and response. The automatic identification system developed in the 1970s is the primary vessel tracking capability for large ships. This capability has been extremely successful and it is used in a broad range of operational settings. However, the reality is that the cost and infrastructure of AIS result in less than 1 percent of all vessels using it.

There is a long-identified need to better support small vessel operations through enhanced identification and tracking capabilities. In 2010, the Department of Homeland Security issued a small vessel security strategy that outlines many issues relating to this. In 2010, the DHS S&T Directorate, Borders and Maritime Division issued a small business innovation research program topic looking for innovative new small vessel identification and tracking technologies.

My company responded with a proposal titled, "Smart Chart AIS," and set forth the concept that, since virtually all small vessel operators also had smart phones, a surrogate AIS capability could be developed that took advantage of these already-present systems. This resulted in development of the Smart Chart AIS app that is distributed for free to the public. Features in Smart Chart AIS include NOAA charts, weather radar, cruising guide information, social network functionality, augmented reality capability, and, most importantly, surrogate AIS capability for small vessels, referred to as AIS-i.

AIS-i is a new protocol we developed for use over the wireless Internet. We are putting this protocol into the open domain, and have engineered it so that any company can integrate the protocols into their equipment. The intent is to enable all small vessels to use AIS for free or at very low cost.

The recent conference was convened at the California Maritime Academy titled, "E-navigation Underway." E-navigation is defined as the harmonized collection, integration, exchange, presentation, and analysis of maritime—of marine information onboard and ashore by electronic means to enhance berth-to-berth navigation, and related services for safety and security at sea and protection of the marine environment. I presented a paper titled, "AIS-i: Supporting the Recreational Boating Community Over Wireless Internet," which was enthusiastically received. Attendees included senior Government and industry personnel from around the world.

This led to an invitation to an invitation by the Radio Technical Commission for Maritime Services, for RTCM, for me to make a presentation at their annual technical meeting. RTCM is an international body that creates standards in documentation that are referenced by the International Electronics Commission, and the U.N.'s International Maritime Organization, in establishing and sometimes mandating performance standards.

An outcome of the meeting was a unanimous committee vote to have two special committees evaluate and report on having AIS formally reviewed and incorporated into the international standards process. This is the first step in a process leading to AIS-i protocols being adopted on a global basis.

The protocols and service that have emerged from this project are gaining national and international recognition as an appropriate and clearly needed solution that will enhance maritime safety and security. The project is rapidly transitioning from an R&D phase to a transitional phase, in which standards will be finalized and formally adopted. Continued support for these efforts will ensure that homeland security interests are addressed, and that the U.S. will provide the leadership needed to enhance the safety and security of the 99 percent of the maritime community that small vessels represent.

Thank you again for your interest and focus on this important subject.

Mr. HUNTER. Mr. Moore, you are recognized.

Mr. MOORE. Chairman Hunter, I wish to thank you, Ranking Member Garamendi, and all the members of the committee for allowing me to participate in this hearing. I am Casey Moore, president of Sea-Bird Scientific. I am here today. I represent the over-200 scientists, engineers, and other associates that comprise our company.

Sea-Bird Scientific develops and manufactures oceanographic sensors. Our products measure physical, biological, and chemical properties throughout the ocean. Examples include temperature, salinity, nutrient concentrations, and ocean pH. They play an increasingly important role in ocean observing.

Ocean observations are not a new concept in supporting maritime operations and response. For example, sea-state parameters such as wave height and tides have been used by the Coast Guard and maritime industry for years. What are new are the technologies, advancements, and sensors, platforms, and communications that allow for detailed ocean monitoring within the water column from shore and from space. Networked together, these tools are changing the game.

Over the past decade in the U.S., there have been efforts initiated to implement this network on a national scale. Local and regional ocean-observing systems teaming with Federal agencies, academic researchers, and public stakeholders work to begin forming an integrated ocean observing system, or IOOS. IOOS serves an increasingly important role in managing the observing infrastructure.

This infrastructure, still nascent in terms of maturity, results largely from public investment. I contend today that we need to invest more. I know this is not a popular notion, in light of our continuing budget deficits, but I hold the conviction that it is in our

country's economic, social, and strategic interests to fully develop this network.

As just one example of modern ocean observing at work, I will touch upon an event that is still fresh in our minds. In late 2012, Hurricane Sandy exacted heavy damage on the eastern seaboard of the U.S. Less publicized was the fact that significant damages and possible loss of life were averted through the use of regional IOOS assets.

A summary supplied by the Marine Technology Society to NOAA's National Ocean Service indicated that IOOS buoys and moorings enabled far more focused preparation and response. Observation and forecasting information resulted in a diversion of commercial container and Navy ships out of the storm's reach for a savings of $6 billion to $7 billion. They also prompted evacuation of over 30,000 people living on first floors and in basements in Hoboken, New Jersey, before the storm surge completely inundated the city.

While these events in many ways validated the utility for ocean monitoring, they belie an important point: We could have done better. Current observing capabilities along the east coast are only a fraction of those envisioned by IOOS planners. Denser sampling would have further reduced risk and uncertainty and preparation and response.

As one specific example, higher spacial resolution vertical sampling of ocean temperature would have provided greater accuracy in determining the storm's intensity at landfall. This could have saved millions in preparation and better enabled response efforts.

A fully capable ocean observing network requires substantial investment. Independent studies provided to IOOS show that costs for a full build-out and operation of a national observing network will exceed $3 billion annually. This is a large number, but it is important to remember that approximately 45 percent of our country's GDP is now concentrated in the coastal regions. Economic and human impacts of ocean events and our need to effectively regulate and respond will only increase.

One common model we use in describing the future of ocean observing is that we see networks and systems eventually growing into an analog of the national weather network. This analogy is apt. Effective monitoring of the ocean extends our ability to—excuse me—greater acuity and understanding long-term weather patterns. It also reduces uncertainty in near-term events.

With greater forecasts and real-time understanding, we can better manage resources to mitigate and respond, as opposed to simply falling victim to changing conditions. This will not only benefit the fisher in Oregon, but also the farmer in Kansas.

I once again wish to thank the committee for the opportunity to provide testimony in this important matter.

Mr. HUNTER. Thanks, Mr. Moore.

Mr. Rosenberg?

Mr. ROSENBERG. Thank you, Chairman Hunter, Ranking Member Garamendi. My name is Dean Rosenberg, and I am the CEO of AIRSIS, a software technology company focused on the energy and transportation industries. Our PortVision division provides patented tools and technologies to increase maritime domain aware-

ness and improve safety, security, and efficiency in the maritime industry.

PortVision maintains a global network of VHF receivers that detect collision avoidance signals, also known as automatic identification system, or AIS, transmitted by vessels around the world. As many of you know, AIS transponder use by vessels larger than 65 feet has been mandated by the Coast Guard since 2005. Its original purpose was collision avoidance at sea.

However, shortly after AIS went into widespread use, we realized that the same data used aboard vessels could also provide significant value to shoreside personnel who needed to solve business problems. So, in 2006, PortVision was born, leveraging federally mandated technology, and repurposing it to drive additional benefits across the maritime industry.

Now, in 2014, our PortVision AIS network processes over 50 million real-time vessel position reports each day, and we store over 40 billion arrival, departure, and individual vessel movements. To put this another way, during every second of my testimony today, PortVision is processing another 500 real-time vessel positions from around the world. Our customers use this data to improve many types of operations, whether it be scheduling of vessels at an oil refinery, supporting an incident response operation, or supporting homeland security and law enforcement activities. There are over 3,000 PortVision users leveraging AIS for these and other valuable purposes, including vessel operators, marine terminals, Government agencies, and every major oil company.

You can think of our network as a commercial version of the Coast Guard's nationwide AIS initiative. However, while NAIS is focused primarily on aggregating AIS data around the U.S. and its territories, we have extended our network globally. Additionally, the NAIS initiative is focused on AIS data acquisition for use in VTS and related operational environments, whereas PortVision is focused on analysis and harvesting of that data to drive business intelligence in the maritime domain. Our observation is that current Government systems appear to be good at collecting and displaying real-time data, but not necessarily in aggregating and making it broadly accessible to field personnel, who must clearly understand waterway utilization in order to carry out their mission objectives.

AIS continues to grow in value. We participate in maritime industry groups around the country that rely on our data and expertise, and we are regularly called upon to provide data and testimony associated with key incidents, such as the Deepwater Horizon oil spill, major hurricane and weather events, and numerous compliance and law enforcement activities.

AIS is also helping the maritime industry accommodate a new surge of Gulf traffic, including vessels transporting crude oil shipments from new finds in the Dakotas, west Texas, and other locations. We are a key enabler in this new and evolving chapter in our Nation's energy evolution.

Another promising development is the use of AIS in pipeline, bridge, and offshore asset protection. PortVision partnered with CAMO, an industry trade association of coastal and marine operators, on a system that proactively notified vessels and pipeline op-

erators when there is imminent risk that a vessel might damage pipeline infrastructure. Over the last two decades, there has been over $100 million in property damage, and over 25 fatalities associated with coastal and marine pipeline incidents. Our project with CAMO has received Coast Guard approval, and FCC approval is pending.

Still another application is identifying bad actors and driving regulatory compliance. For example, PortVision has partnered with the Offshore Marine Service Association to identify and report Jones Act violators, while individual port authorities use PortVision to enforce speed reduction initiatives. Other Government customers use PortVision data and services to support homeland security and intelligence operations. These value-added benefits are only possible if carriers transmit a persistent signal with accurate data.

We know of no uniform enforcement by the U.S. Coast Guard to ensure that carriers comply. Some VTS regions are very vigilant about compliance, while other regions have less active oversight. I urge the subcommittee to ensure that all vessels required to transmit AIS maintain a consistent, uninterrupted, and accurate AIS transmission, to ensure that these valuable AIS technology initiatives can continue.

Finally, I seek the subcommittee's support in encouraging Federal agencies to look to commercial sector and small business to help execute their maritime domain awareness initiatives. Companies like ours provide proven valuable services at very low cost. However, commercial offerings like PortVision are often overlooked in favor of reinventing the wheel through Government-funded build-versus-buy initiatives. This not-invented-here culture can put up barriers to Government adoption of proven and widely deployed commercial technology. It also prevents many Coast Guard and other Government field personnel from operating as effectively as industry partners who have access to these tools.

Thank you again for the opportunity to share our story. We believe that blue economy companies like PortVision are key enablers of enhanced maritime domain awareness, and increase safety, security, and efficiency across the Marine Transportation System. I look forward to your feedback, and happy to answer any questions.

Mr. HUNTER. Thanks, Mr. Rosenberg.

Commander Slayton, you have an interesting bio. You have been in the Arctic since you were 17—13——

Mr. SLAYTON. I was 13, and joined the Navy when I was 17, and have probably spent about 3 years, total, operational time in the High North, between all the Arctic nations.

Mr. HUNTER. It is all yours.

Mr. SLAYTON. Save Russia.

Mr. HUNTER. Right.

Mr. SLAYTON. Chairman Hunter, Ranking Member Garamendi, and members of the committee, thank you for the opportunity to appear before you today. It is indeed an honor and a privilege to talk to the committee about the creation of new and emerging ocean technologies, how facilitating their development would expand maritime entrepreneurship, job development, and commerce,

and further our understanding of the ocean environment in support of vital U.S. interests in the maritime domain.

Additionally, I am glad to discuss what we at the Hoover Institution and the Arctic Security Initiative view as impediments, barriers, and factors that limit or constrain the creation and use of such technologies and their applications. These technologies we discuss today will become increasingly important as we witness the convergence of climate change and national security challenges, a convergence clearly recognized in the High North and other regions around the world, and ably identified within the 2014 Quadrennial Defense Review, the National Climate Assessment, the Intergovernmental Panel on Climate Change, and, most recently, in the Center for Naval Analyses' Military Advisory Board report.

As recent events in Russia highlight, coupled with the effects of climate change, the Arctic has re-emerged as a significant strategic territory: in part due to the region's abundant energy, mineral, and natural resources, and in part due to increased maritime access to the area. That being said, we in the United States need to be prepared, at a minimum, with greater Coast Guard and Navy presence, monitoring capability, and infrastructure capacity. Presently, we are not prepared, and we are far from being ready.

In this context, when we evaluate maritime security requirements, the U.S. and other Arctic nations require the capacity and capability to support, respond, and react to the events that are taking place now. Moreover, as we have said, security is also about safety, adequate naval response, environmental, humanitarian assistance disaster relief, and commercial accidents that might take place in the High North. And it is there that our Coast Guard is going to be on the front lines that—anything that happens in the Arctic.

Last year, the Navy, Coast Guard, DOD, and the President all released policy documents on the Arctic. All the policies called for new technology capabilities, infrastructure capacity. The documents, together, make up the nascent U.S. Arctic strategy—however, unfunded.

Then, in January of this year, President Obama released the U.S. implementation plan for national strategy for the Arctic region. The plan is an integrated Arctic management process with a clear objective to engage with the State of Alaska, Alaska Natives, and key stakeholders and actors from industry, academia, and nongovernmental organizations.

For the maritime domain, the plan presents a 10-year horizon that will be used to prioritize Federal infrastructure in the U.S. maritime Arctic. It is not surprising that within the section of the maritime domain the plan calls for recommendation for Federal public-private partnerships, a recent subject of this subcommittee to support the prioritized marine infrastructure elements that are to be developed in Federal projects. This may prove to be an early indication that, without investment partnerships with the private sector, new initiatives such as maritime-centered economic development may be constrained or limited by the Federal budget process.

Closely aligned with the subject of this hearing, the plan recognizes a number of key requirements that relate to the changing U.S. maritime Arctic and its future. Included are major technology

initiatives on developing telecommunications services; enhancing maritime domain awareness; sustaining Federal capacity to conduct maritime operations in ice-covered waters—rated as icebreakers in a capacity to break ice; increasing charting in the region; and improved geospatial referencing; oil and other hazardous material spill prevention, containment, and response in supporting the circumpolar Arctic observing system.

This is just a subset of the many tasks presented in the plan. However, it is clear—very clear—that the maritime domain requires special and timely attention, using integrated approaches that can respond to a broad array of national security challenges.

In closing, while the issues are many and not without challenge, the maritime industry and the maritime entrepreneurial centers of this Nation afford great opportunities. Now is the time to approach our maritime and our Arctic interests and responsibilities urgently and with national strategic priority.

Thank you again, Mr. Chairman, Congressman Garamendi, and the members of the committee, for the privilege of appearing before you. I look forward to the remainder of the hearing, and I look forward to answering your questions.

Mr. HUNTER. Thanks, Commander. We actually figured out what the Navy and Coast Guard's plan was for icebreaking. It is to wait until it melts, and then we won't need one any more. Right?

It is a joke. Come on, it is a joke.

[Laughter.]

Dr. Terrill, you are recognized.

Mr. TERRILL. I would like to start first by thanking Congress and the Federal agencies in their ongoing support of ocean technology development and sustained observations of our oceans, as this investment has made the U.S. a leader in the development, manufacture, and applications of ocean technology.

This investment not only allows U.S. companies to compete successfully in the global economy, but the investment in ocean science and technology creates jobs and strengthens and supports U.S. national security. And, for better or worse, I am actually a product of this investment, and I have spent the better part of my career in a close relationship with this ocean technology, ocean research, and Federal agencies, whose missions depend on timely and accurate data.

For maritime domain awareness to be responsive to emerging needs, the U.S. Government needs to consider partnering internally across agencies and externally to industry and the research community. In the present economy, this leveraging can't be understated. In addition, we need to consider better approaches to procurement programs that serve national MDA needs, as all too often new technology and concepts of operations sink before they can even take off, because their price tags are too high.

One existing framework that we have heard earlier about this morning is the Integrated Ocean Observing System. This was initiated only 14 years ago as an interagency planning effort, and already has a formal program office at NOAA and 11 regional associations that are collecting observations and serving them up to a diverse stakeholder community.

And, coincidentally, the Integrated Coastal and Ocean Observation Act of 2009 needs to be reauthorized.

IOOS has many successes, including providing on-scene environmental information in many extreme events that the country has faced, including Hurricanes Katrina and Sandy, the Cosco Busan oil spill in San Francisco, and the Deepwater Horizon oil spill in the Gulf of Mexico, to name just a few. In all these cases, IOOS has acted as a decision support system, and the observations provided many of the behind-the-scenes data that was used by local, State, and Federal responders.

Ocean technology that is the foundation of this IOOS system is a network of high-frequency radar systems that provides 24/7 maps of ocean currents around the coast of the U.S. Data are used to support oil spill response, search and rescue, water quality tracking, fisheries management, and marine protected areas, and it is one example of how the U.S. Coast Guard and other Federal agencies rely upon NOAA through MOUs to provide operational ocean data. It involves 31 organizations maintaining 133 radars now, and my group at Scripps was intimately involved in the design of that data management system that is functioning now at the National Data Buoy Center.

One exciting next step for the technology is to apply it for ship-tracking applications. And just recently there were some tests in the Philippines by U.S. Pacific Command, Office of Naval Research, Scripps, and the radar manufacturer to demonstrate this capability, and this builds off of earlier Department of Homeland Security-funded research efforts.

However, the opportunity for the U.S. to transition the U.S. HF Radar National Network to having this capability will remain elusive because, right now, the national network is funded at $5 million a year, which is half of the $10 million a year required to reach 100 percent capacity. And the program budget for this effort has remained flat in NOAA since receiving its own funding line 3 years ago.

Another example of potential partnership and transition for coastal MDA needs is the repurposing of land surveillance equipment returning home from Afghanistan. With the war drawing down, opportunities exist for repurposing the investments and surveillance aerostats and towers equipped with X-band radar and cameras. These systems were originally developed to provide force protection of forward-operating bases. In the same suite of sensors, a networked architecture, with some modifications, are well suited to providing this type of capability in a maritime environment for providing detection of offshore vessels, illegal fishing, and providing port and harbor security.

Maritime evaluations of these technologies are timely and currently pursued on a pilot level by the NAVAIR, Naval Air Systems Command, and Office of Naval Research. And this summer, two systems will be deployed overseas as part of a demonstration effort with PACOM. So I would encourage looking at how other technologies and working with the defense research enterprise can be capitalized within partnerships with the U.S. Coast R&D center, because I think they would be low-cost and provide a high return on investment.

The Arctic also presents another set of challenges that we have heard about. Ocean technology is going to be required to provide the kinds of observations necessary to understand the oceanographic and ice conditions that will exist up there. Right now we don't have those technologies in place, and the environment is highly undersampled. So partnerships developed with the Navy, NOAA, National Science Foundation, DARPA, and U.S. research organizations should be considered to leverage the respective investments of those groups.

So, to close, I encourage partnerships across agencies, fund pilot demonstrations that involve the research enterprise and industry, and let's build U.S. MDA capabilities from our existing modern-day successes. Thank you.

Mr. HUNTER. Thanks, Doctor. I am now going to recognize Members, starting with myself.

Let me just say, first, it is great to have everybody here. You know, we can't force Government agencies, no matter who they are, to adopt any kind of technology, right? But what we can do is make sure that they are not recreating what you are already doing inside the Government bureaucracy for 10 times as much as you are doing it for.

But that is what we can do, and that is one thing we are going to basically look at after this, to see all the stuff that is out there, what is going on, and make sure that they are not trying to recreate the wheel, especially if the technology already exists.

So, to start, Mr. Rosenberg, let me ask you to, if you would, demonstrate this. And, two, if you could, talk to how this is different than any other kind of common picture operating system that the Government uses, or AIS. What is different about this and separates it out? If you could, talk to that as you demonstrate.

Mr. ROSENBERG. Yes. So, PortVision—so if you look at the NAIS initiative, it is really focused on the aggregation of data, of the aggregation of AIS data. What we are trying to do is make business sense of that data. So, if you look on the monitor, we are looking at the live version of L.A. and Long Beach right now. And I have highlighted the MSC Luciana. What we are doing is not only showing kind of the traditional points on a map common operating picture, but we are also providing additional sort of maritime business intelligence.

So, in the events list we see when this particular vessel departed the Shengdong container terminal in China, when she arrived at San Francisco, and when she ultimately arrived at the Hanjin terminal in Long Beach. So we are really trying to solve sort of business problems, or have a more thorough understanding of what is going on.

And then, we take that further to actually getting into the reporting aspect. So I have brought up that TTI Hanjin terminal in Long Beach, and I am now showing very detailed information about every vessel arrival, the type of arrival, the draft before and after, which implies loading or unloading, where that vessel came from, and what its next destination is.

Most of the Coast Guard and Government systems don't get to this level of MDA-type understanding. They typically are more fo-

cused on sort of the real-time points on a map, and seeing where a vessel is right now.

Mr. HUNTER. So how does this help you solve——

Mr. ROSENBERG. So, what we found is—you know, my contention is, today, you know, today, on Wednesday, there are dozens, if not hundreds, of field personnel and Coast Guard and Government agencies in the U.S. that need information about current real-time and historical data. They don't have it, but their industry partners do. You know, some other personnel need information to look at compliance activities or law enforcement or litigation activities. They don't have it, but their industry partners do.

And we have lots of sort of anecdotal stories around Coast Guard and Government personnel calling on industry partners to get the data. Because, at the field level, at the field personnel level, they don't have access to these systems. In the VTS office, in the headquarters, in the command center, they have access to all sorts of common operating picture technology. But at the field level, where people are actually doing their jobs deployed, they don't have that information.

So, I mean, our technology, other technologies like ours, are Web-based, they are PDA-based, they are smart phone—it is pretty easy, certainly.

Mr. HUNTER. I have a question, kind of a general question for everybody. When it comes to hiring people—this probably is outside of the software world—but in the actual blue technology manufacturing part, or R&D, where do you hire from? What ages do you hire? How hard is it to get people that know what they are doing with their hands and making stuff? Or do you find it difficult, or is it not difficult? Do you have plenty of folks out there to hire? Anybody? Everybody.

Mr. ALTSHULER. I will start with that. We actually find hiring very difficult. So we want highly skilled technicians. We need very good engineering skills. The ocean is an incredibly complex environment. There are limited numbers of ocean engineering programs, and those programs are probably underfunded, from a standpoint of the research and development in grants they get. So it is a slow, organic growth of that skill set.

When you look at the economy, the blue economy, it is going very quickly. So it is definitely underrepresented, from a standpoint of what we can bring in, as personnel. And I would guess—I would like to hear what other people see. But offline, many of the gentlemen here I have talked to in the past, and they would say the same thing, I would think. So——

Mr. MOORE. It is a challenging environment to hire in the Northwest, because we find ourselves competing with industries such as Microsoft in the Seattle area for capable engineers, industries such as Boeing. On the other hand, we don't expect or—we don't expect the level of turnover. So when we do hire, we invest in individuals, and it is usually a long-term venture. So there is very little turnover in our business with professionals, and it tends to work out in the long run.

Mr. SLAYTON. I will take a stab at this one, as well. Yes, I admire the tenacity and the entrepreneurship of the gentlemen that sit to my left. And being up in the Bay Area, we are a stone's throw

away from Sand Hill Road, one of the largest concentrations of venture capitalists in the United States. Also, sitting on the campus at Stanford University and having other great universities like UC Berkeley, Santa Clara, San Jose State nearby, we have the opportunity here about the challenges and the barriers to starting these ventures, first and foremost.

Going to sea inherently is already a dangerous situation. And to try to lure and entice investment in that area is challenged by who is going to underwrite these areas. Again, the folks that are going to be hired that we put out to sea likewise have a reasonable expectation that they are going to receive and be compensated in that way.

So, again, I understand and fully realize the challenges that these gentlemen face to find a capable workforce on top of trying to fund their initial enterprises, going forward.

Mr. TERRILL. I would like an opportunity to——

Mr. HUNTER. Go ahead, sure.

Mr. TERRILL [continuing]. Address a little of this, as well. As a federally funded—primarily federally funded research organization in La Jolla, obviously, the cost of living is pretty high for young, entry-level technical staff to be joining us and living locally. But we are able to tap into the nearby universities, 20,000 strong, a lot of engineering students, physics students.

And, as others have mentioned, a lot of technical staff, it takes them about 10 years before they are really useful and independent, because it is such a cross-discipline field that we are working in. We need engineers and technical staff that don't get seasick, know their way around, how to turn a wrench, but also are technically competent at the cutting edge of new technology, whether it is electrical engineering, or mechanical engineering, or the sciences.

And so, we do have retention issues, but what we have found is, through internships and through tapping into the local universities, we are able to hire in employees. In fact, a lot of our employees, after they have been with Scripps for a number of years, they often are highly sought-after by industry because they have that real-world experience of their butts on the line to make equipment work, and they are sought after by industry to do the same for them.

Mr. HUNTER. Last question here in the last minute. What do you all see is the next step in the next 20 years? Like, when is the next—what is the jump going to be to when it comes to maritime technology and science? Is it in the mapping arena? Is it in the exploration arena? Just curious. Where do you see things going in the next quarter century?

Anybody. Yes, please.

Mr. BENTON. I think e-navigation is going to have a huge impact. Essentially, the world is becoming networked, and that is happening in the maritime environment. There are initiatives in Europe and elsewhere globally to move that forward. And I think the U.S. is a little bit behind the curve in participating in what ultimately is going to be an architecture that is open, that anybody can both contribute information to and get information from.

So, I think it is important that funding and just Federal focus be given to that, more than it is today.

Mr. ALTSHULER. I would add to that. The—you know, on the networking thing, I think we have just talked about networks that are above the water. But probably the growth of sub-sea underwater networking is going to change how we do ocean observation, how we do security, port security, deepwater military operations, blue water operations. We have seen a little bit in the last few years of these observatories. They are relatively simple networking systems.

You know, as we go to independent systems that are—use acoustic communications, that use optical communications, what you will see is the ability to distribute data, to distribute sensing, and exiltrate that information back to the resources that need that. And, as I said, that can be science, and that can be national defense.

So, we are investing heavily in that area. We think that that is a huge growth market. And we see the rest of the world, and specifically China, very interested in that type of technology.

Mr. MOORE. I presented in my discussion the concept of moving to a paradigm similar to the national weather network. I think that is apt for reasons mentioned.

But I also want to consider it or wish you to consider it in terms of how the national weather network is now used, and how little idea we had in—50 years ago as to how it would weave itself into our social fabric so deeply. I think that that same basic truth holds as we expand and develop these ocean monitoring technologies, both within and through remote sensing capabilities, and bring these networks together.

Mr. ROSENBERG. Yes, I think on the AIS front it is really going to be around industry collaboration. I mean AIS was really just legislated for collision avoidance, but then industry ran with it and came up with all of these other benefits. And so, we see transmission of AIS signals being able to automate a lot of the activities that are now done by a radio, or that are now done many days in advance.

Mr. SLAYTON. I will build on the comment that was made earlier about the blue economy growing. And it is growing because we have just added another ocean to the planet. The Arctic is opening up. There is a huge need for hard infrastructure, deepwater ports, and associated infrastructure that goes along with that, as well as the networking that is going to be required to bring folks together in the High North. Once you get above about 65, 70 north, it becomes very challenging to communicate, particularly at the level that we are used to, here in the mid-latitudes, in the bandwidth that is required.

Mr. TERRILL. One revolution I see us going in the next 20 years is the reliance on unmanned systems. Just as we are seeing in the aerial domain, underwater unmanned systems, surface unmanned systems on the ocean surface are really revolutionizing the way we do ocean science right now. We are sampling the earth, earth's ocean, at a resolution that is unheralded to date. Right now there is over 1,500 profiling floats that sink down to 2,000 meters and surface every 10 days to give us a sense of how much ocean heat is present in the earth's ocean.

Another revolution I see is the ability to do very precise forecasting. So, just as we have precision agriculture that is doing very

high-resolution agriculture, we are going to see that with weather and in the ocean world. That sort of level of precision will be surfacing that we can take advantage of, and that will be able to take advantage of all the tools to be able to exploit these unmanned sensors that are going to be deployed.

Mr. HUNTER. Thank you all. Mr. Garamendi, our ranking member, is recognized.

Mr. GARAMENDI. For all of you, thank you so very much for fascinating and extremely important testimony. One hardly knows where to start, as we cover the total spectrum of what you have put before.

I think what I would like to do is to go back to a couple of questions that were raised a moment ago and push them forward, about the personnel side of this, and the research side of it.

There is a markup going on very soon in the Space and Technology Committee that is going to reauthorize much of the underlying authority for research. Don't know if any of you gentlemen have been following that. There are some concerns that exist about that potential markup, particularly the level of funding available for the social science part of it. I was just thinking about how we would have been better prepared for the Iraq War if somebody had thought about the social science piece of that war.

There is that, and there is the overall funding issues. And, back to the educational piece, which I think two of you gentlemen are specifically involved in, or at least nearby, and the rest of you are dependent upon.

So, let's talk about the research budget, the legislation that is going on around here, the reauthorization of that, if you followed it, how you see that coming together. And then, on the—how that research also—the research budget ties in with the education and the future employees of the private sector, as well as the public sector side of it.

So, let's start, I don't know, left to right. But we will start with Scripps and move down the line here, quickly.

Mr. TERRILL. Well, thank you. Certainly one of the things the country depends on is continuity and steadiness of research funding, so that that continuity of civilian workforce, being at the cutting edge of developing new tools and capabilities, can transition to the industry and the Government. It wouldn't be there if we didn't have that continuity. So I would support you on that, that we need to have that in place.

I am not familiar with the specific markups that you are referencing, but we definitely need to keep that research budget healthy.

Mr. SLAYTON. Likewise, I agree with what Dr. Terrill—again, being based at the university, and seeing the amount of dollars that flow in from the National Science Foundation and a number of different grants that support some of the things we mentioned today, particularly the underwater vehicles, the expanded network capability, and the deeper research that is going to be required, particularly in the oceans, I think it has been mentioned on more than one occasion we know more about the moon than we know about parts of the ocean.

Again, I will go back to the area that I am involved in right now. Currently, only 10 percent of the floor of the Arctic is mapped. And at current projections, it is going to take another 70 or 80 years to complete that job for our Navy and Coast Guard and our professional mariners, going forward.

Mr. GARAMENDI. Let me stop there for a quick second. How does your organization work with the U.S. Navy on this question of the Arctic?

Mr. SLAYTON. We have tied with the Navy, informal for the most part. We have one active-duty naval officer that participates at the Hoover Institution, as well as we are always open to inform the Navy and the Coast Guard, really, any service on the work that we are doing. All the research and all the analysis that we do is available publicly, and we are always glad to support the DOD and the services.

Mr. GARAMENDI. Be very specific. The Coast Guard has some— we have some interest in this committee with the Coast Guard. How do they work with you?

Mr. SLAYTON. There is no direct ties at this point.

Mr. GARAMENDI. And——

Mr. SLAYTON. Other than informally advising the Coast Guard.

Mr. GARAMENDI. OK. Let's continue on with the research side of it, the importance of research on down the line. I suspect the answer is "extremely important," but——

Mr. ROSENBERG. Right. It is. We are not directly engaged in a lot of Government-funded research, so my concern is mostly around the recruiting side of it. So the two dimensions of, you know, more STEM awareness at an early age, from middle school going on into high school, and then also broadened awareness of our maritime academies and the ability to generate some more maritime DNA that can enter the workforce.

Mr. MOORE. The three companies that came together to form Sea-Bird Scientific, all three started as very small startups that basically were holding direct relationships and were coming from researcher community, building from science and research dollars, supporting the research environment, the research environment within the United States, supporting these companies as they have grown.

Presently, we have shifted focus to much more operational programmatic efforts. That is, in part, because that is where money is these days. We would look at trying to do what we did now. In other words, trying to start up a science technology business in oceanography, especially within the ocean observing, I think it would be a very difficult road at this point in time. So, as beneficiaries, we are thankful, but we have really seen that tide shift away from research support.

Mr. BENTON. My company has been involved in small business innovation research for 25, 30 years now. And we are highly ranked in our ability to commercialize stuff. But Dr. Terrill mentioned continuity in funding. And one of the huge issues that we run into is that you can have a project that is successful and then is orphaned because there has not been any thought given to the budgeting process to take something that is ready to transition and

let it get enough legs so that it can be supported by private industry.

So that would be my biggest recommendation, is to make sure that funding that does go out there is spread across the whole TRL level, so that people can actually get their basic research transitioned into an operational condition that will benefit the economy and us.

Mr. ALTSHULER. So, first of all, I think I would support strongly my colleagues here that are advocates for a strong research budget. I think there are a couple things we need to think about, though, and the first is what do we do relative to small business, to product development relative to large science programs. Large science programs drive industry in what they invest. And industry invests heavily here.

From a self-centered standpoint, I started out in my remarks saying that we are a $600 million business at Teledyne Marine. We probably invest $50 million a year in product development, in research and development internally, and then we have a fraction of that, and probably a smaller fraction than most would think, that is federally funded. Where we sell is into the science programs.

So, it is a multiplier effect. If the science programs have long legs, they are well thought out, and continuous, then industry has the ability to grow around that. And so, I think that is really critical, that we build something that is going to drive the rest of businesses here to invest their own money into growing that economy. Our—the worldwide community is doing that, and the worldwide community is copying what the U.S. is doing right now.

Mr. GARAMENDI. I have run well over my time. I will make a couple quick comments.

The science—the Federal funding for science programs in this particular area, in the oceans and ocean observation, often wind up at research facilities like Hoover or Scripps, both of which are connected to universities, and I suspect it is similar around the United States. That funding not only deals—not only provides the basic science, and whatever comes from that, but it also provides the education for the engineers, the scientists, and others. Those are the fellowships, the—and the rest that flow from that, so that the funding for science is also the funding for education, which is the foundation for the workers that the private sector needs.

And so, as we move this issue forward, if we are going to deal with this, we have to come back to the research piece of it and make sure that that has long legs, that it is—that there is continuity, and, in this particular area, that it is available for the ocean sciences in the broadest sense of it. Unfortunately, we are not going in that direction. The clear indication is that we are backing away from funding basic research.

There are folks, as you say, in Sand Hill Road that are happy to pick up—that used to be happy to pick up this. Now they want to have a quick turnaround with some sort of an app for the iPhone. But hopefully they will get back to more basic things that actually have—longer lasting than an app that disappears in 6 months because it is replaced by another app.

I think I had better yield back; I am at least 4 minutes and 45 seconds over my time.

[Laughter.]

Mr. GARAMENDI. Mr. Chairman, thank you for the——

Mr. HUNTER. Thank the ranking member. Mr. Rice is recognized.

Mr. RICE. Thank you, gentlemen, for being here today. This is very interesting to me. I live on the ocean, and I am an avid fisherman, spend a lot of time on the ocean, and truly enjoy it. And there are a lot of questions I have, being from Myrtle Beach, South Carolina, which is a resort town, and somewhat in Hurricane Alley, maybe on the edge of it. Living there for decades, and seeing hurricane prediction, and predictions of how many hurricanes are going to occur, I have to see the—I believe the University of Colorado just said, "We are not going to do this any more, because we can't get it right."

They seem absurdly inaccurate. Almost every single year. Are we making any progress in this type of prediction? I mean I know it is very difficult to understand these earth systems, but are we making progress?

Mr. TERRILL. Well, I see some eyes looking towards me, so I will take a stab at this.

[Laughter.]

Mr. TERRILL. I have actually been involved in hurricane research at some level, and so I would like to make some comments that the longer range forecasts that University of Colorado used to put out, it was a very difficult problem, because of the way that the chaos of the system that we are dealing with.

Where we have seen steady improvements every year is in our ability to track forecasting. So if you think about hurricanes and the evacuations that you have experienced, some estimates I have seen cost about $1 million a mile of coastline to evacuate shorelines. So the more we can improve track forecasts, the better. And we are getting there.

The difficulties we are having right now are in intensity forecasting. And sometimes that threshold of when you evacuate is based on what are the strength of the winds, and what will those winds be 24, 48 hours out. And the reason our intensity forecasts are often lacking is because we don't have good information about the ocean heat content.

Hurricanes are a thermal engine. They depend on the amount of heat that is in the upper ocean available to fuel the storms. By being able to have better observations of ocean heat up near the surface, it will give us better intensity forecasts, and that has been demonstrated.

But, I agree, those long-range forecasts, that is a gambling man's game to be in. But that shorter term forecast, I think we are making progress.

Mr. ALTSHULER. Yes, I would like to comment a little bit and add to what Dr. Terrill said.

Probably one of the most successful ocean observing programs worldwide is called the Argo Program. And Scripps has a major position in there. Teledyne has a major position. We supply two-thirds of what are called profiling floats that measure the heat, or the thermal properties of the ocean, down to 2,000 meters. And there are some new systems that will go all the way down to 6,000 meters. Those allow the ocean modeling, which understands the

heat content, and thus understands the energy budget when you have these types of storms. That is one big piece of it.

The next is more of a tactical piece. And there are some new efforts—again, coming out of NOAA and out of IOOS—called storm gliders. So they are looking at underwater autonomous vehicles that are put out in front of the storms, still out at sea, still well away from the shoreline to—really, to start to understand the ocean mixing. Because that is the other piece of this that becomes very important, is as the storms come through, the dynamics of the ocean become different than in the steady-state environment, and that changes how the storm gathers energy, and how the storm intensifies or doesn't intensify.

The best example of this is probably looking at the loop current within the Gulf of Mexico, and what are called core eddies that shed off the loop current in the Gulf of Mexico. These are very warm pockets of water. Satellite imagery does not really tell you how big they big they are and how deep they go. But as the storms go over, if they go over a core eddy, they can grow from a Category 1 or 2 storm to a Category 5 storm very, very quickly.

So, it is a very important process to study the—actually, the full 300 or 3-dimensional heat budget of that ocean to be able to deal with those types of models.

Mr. RICE. As an offshore fisherman, I would look at sea surface temperature charts to try to find those eddies, because often the fish are in those very eddies.

So, what I am hearing from you is that we are improving in tracking and short-term forecasting, but that, really, there is not a whole lot of progress in long-term hurricane numbers, intensity, all those types of things. Is that correct?

Mr. TERRILL. That is correct. The last large science efforts actually came out of the Department of Defense. Office of Naval Research sponsored large programs to study the rapid intensification of storms, and developed a lot of these unmanned technologies we heard about. And we are making improvements, but what we are finding is the ocean is undersampled. So if we have the data points, we can actually get those intensity forecasts a lot better, take advantage of some of the hurricane P300 aircraft, putting assets right in the path of the storm to get those observations.

Mr. RICE. The other problem I see with data that is erroneous or lacking is in the marine fisheries. I hear a lot from fishermen in my district about the fact that fisheries' seasons are closed, or the timelines are shortened, based on erroneous information in—that the marine life is plentiful, particularly in the areas being closed.

So, is there any improvement in those areas? Can we look forward to improved data?

Mr. ALTSHULER. I will try that again, although this is pushing a little bit.

There are a couple of interesting efforts that are underway. Probably one which is—has U.S. content and has Canadian content is called the Ocean Tracking Network. And the idea is to tag and track fisheries. So, what ends up happening is there is a bottom network of sensors that is watching fish moving around through

certain restricted areas. That is probably the best types of data to get.

From—other than that, it is a really hard problem to go and try to understand. Again, because it is a three-dimensional problem in the ocean, and we really don't understand much below the surface of the ocean.

Mr. RICE. Well, and it is unfortunate, because we are dealing with people's livelihoods. And when you do things like close the black sea bass fishery off South Carolina, and the fishermen can't catch anything else, because every time they put their line down they catch a black sea bass because there are so many of them, it is obviously based on erroneous data. And if there is any way we can improve that.

Has anybody here studied the long-term effects of the Deepwater Horizon incident? I am curious about that. No? The—you know, there is talk of significant oil and gas reserves off of the shores of South Carolina, North Carolina, Virginia. And there is pushback on doing the testing required. The only charts that they have were done 30 years ago, based on antique technology, and they are talking of doing sonic testing off the shores to determine, with new technology, whether or not these reserves exist.

But there has also been pushback because it would damage marine life. Can you describe—can anybody here describe the process of this testing, and how it damages marine life? No?

Mr. MOORE. I can take a stab at it.

Mr. RICE. OK.

Mr. MOORE. At risk of error. In the aftermath of the BP oil spill, there was prospect or promise of funding regional centers using some of the settlement money—State centers, if you will, for excellence, that would be doing various research efforts to study the ecosystems within their local environs. That funding really hasn't arrived at the centers yet. So there has been, basically, a stall in actually doing—going forward.

There is another body of funding that has been funding consortiums from different States in the area that is very research-oriented. That funding has started to flow, and there has been programmatic efforts going on. But from my—I don't have direct knowledge of what progress they have made in actually identifying the impact, long term.

Mr. RICE. Has anybody here been involved in any of this sonic testing at all?

Mr. MOORE. Our sensors, our equipment, our——

Mr. ALTSHULER. So—and I can add to that. So, I think from the standpoint of the surveys, it is what is called a seismic survey, where they use large vessels that have streamers, they have hydrophone arrays that stream back behind the ships, and then they use—right now the current technology is an airgun to acoustically activate the water, and put seismic energy into the subsurface to look for what is called top salt. It is the layer where the potential oil is underneath.

And there are concerns—it is used a lot, but there are environmental concerns relative to that. The type of energy that is put into the water column currently—just to give an idea of technology development, there are—there is a consortium of oil companies, and

a program that is being led out of Texas A&M University at the environmental station down at Texas A&M University to look at other types of technologies, to put energy into that sublayer that has less environmental issues. That would change how you do the surveys.

And then, you propagate to what Mr. Moore has been talking about, which is, once you are there, it is the environmental monitoring. And the things that didn't exist in Deepwater Horizon was the response capability to understand when or if you have that type of an accident, how you respond and how quickly you can understand the oil moving into the water column. Because that oil was moving in at 1,200 meters. And that is—again, as I have said earlier, it is very hard to sample down that deep, and only a few types of systems can actually do good measurements there.

Mr. TERRILL. As you mentioned, the sonic testing is using airguns. And I think you referred to them as ancient technologies. And at those times I don't think we had a good understanding of the impacts to marine mammals. Since then, with the advent of U.S. Navy sonars, and all the testings and investment of research that have gone into them, they have started to put criteria, in terms of the amount of sound that can be put in the ocean with potential damage to the marine mammals.

Mr. RICE. But——

Mr. TERRILL. But there are some mitigating tools now, I think, coming out. Using electromagnetics is one area that oil companies are beginning to use that aren't impactful to the marine life, that provide alternatives to oil exploration.

Mr. RICE. I am way over my time, but thank you very, very much.

[Laughter.]

Mr. HUNTER. When only two or three people show up to the hearing, you are allowed to go over your time. That is the rule.

[Laughter.]

Mr. HUNTER. I have a question. Just if you could, go down the line and give me an example. PortVision is easy to understand. Right? I got that, right? I understand how that is applicable, why it should be used, what it provides.

But in practical applicability, to what different agencies should be using right now to make their lives easier, or to save money, or to save lives, or to be able to do something that they can't do right now, could you just kind of give me, each of you, what do you think we should be using, any Government agency, not—you know, Coast Guard, NOAA, Navy, whatever—what should we be using or seeing that we are not, for whatever reason? Practically, a real example, if you could.

Mr. ALTSHULER. So I will start with a product we make that has been successfully used in the ocean. It is relatively new. There are approximately 500 that we have sold. And that is called an underwater glider. And what it uses is a very slight change in the—whether the glider floats or sinks. It is a buoyancy engine to move up and down through the water column. And it is used to do everything from naval operational ISR to core science—and I mentioned storm gliders—including looking at storms.

This is probably one of the core components to both coastal and deep ocean observation at the first 1,000 meters of the ocean. It is a core element to the ocean observatory's initiative. It is—we see it being used worldwide by academic organizations and internationally. But it is at its fledgling stage. I think that we will see that technology adopted, or we should see that technology adopted over the next 10 years. It will change how we understand the ocean.

And as you go down the group of gentlemen here, and we talk to even some of the other committees, it is really just a truck to take the sensors into the ocean to allow us to understand the bits and pieces of it.

Mr. BENTON. Automatic identification systems, you know, the traditional ones are very successful. And all of the benefits that come out of that also apply to small vessels, when you start enabling them.

So, from the Coast Guard perspective, just being able to track where vessels are, support search and rescue, et cetera, all of that is supported. From Custom and Border Protection perspective, a boat coming over from the Bahamas, gets the cell phone wireless network and lights up, and they can start the clearing process.

Also, the whole Internet use of the wireless Internet to support maritime stuff is equally applicable for spots like the Arctic. The architecture that we are using to support the recreational community fits right into the e-navigation concepts that IMO is looking at. So, the ability to take traditional large vessel bridge information, such as AISA Class A and B, repackage that, and bounce it off an Iridium satellite into a network architecture, enables a whole lot of stuff to start happening to support Arctic operations without putting a whole lot of money into building new infrastructure.

Mr. MOORE. We need his truck.

[Laughter.]

Mr. MOORE. So, the—if we are going——

Mr. HUNTER. If I could—I mean I have been—I have seen a lot of autonomous underwater, nonmotorized vehicles, right, that have that—they use the swell and kind of like the wings that the surfboard—the liquid robotics guys use up in Silicon Valley, or whoever. We had some guys in San Diego that have their own autonomous vehicle that is kind of self-propelled. But I have seen that. So, I mean, that is going to be there.

Mr. MOORE. Yes. And by deploying those, we can address a lot of the problems that have come up in the question and answer period, including better fisheries management, the ability to get the heat—vertical heat transfer in the upper water column for storm prediction of intensity. These types of problems can be addressed using that type of mechanism. And it, right now, seems among the most efficient and cost-effective—and actually using on a widespread capacity, so——

Mr. ROSENBERG. Yes, I think, from our perspective, improving efficiency of commercial vessel movements.

So, at the Army Corps of Engineers, improving predictive forecasting and collaboration around show points on inland rivers, lock management and the ability to support more efficient queuing in and around locks to be more predictive in transit times.

For Coast Guard and Customs and DHS, again, the frontline personnel giving what we call portable MDA or portable maritime domain awareness into the hands of those who have to do boarding, those who have to do incident investigations, and other things that are outside of the command center. And then the other things that I talked about earlier.

Mr. HUNTER. Just really quick, can you do—I mean do you know right now—do they write algorithms that can queue them, the Coast Guard or Homeland Security, off of the information of where the ships are coming from and where they are going to, and that kind of thing?

Mr. ROSENBERG. So, I mean, there are notices of arrival, and there is data around that. It is not typically used for what I call berth rotation scheduling, or for actually improving the efficiency of once a vessel gets to the sea buoy and it moves up to its other activities in and around the port.

There was a funded initiative called LOMA at the Army Corps of Engineers. I believe that that has been defunded, but I am not certain. And that was a home-grown system for doing some lock automation and lock management.

Mr. HUNTER. Thank you.

Mr. SLAYTON. I will talk both for general oceans applications as well as High North, in order, for infrastructure.

Again, applaud the efforts of the Army Corps recently, and the combined efforts of looking at both Port Clarence and Nome for port expansion. I have heard both from State representatives, as well as the local municipal leaders, about looking at some out-of-the-box applications for expanding the capacity and capability of both those port facilities, where some of these proposed floating platforms, particularly based on the geography, and based on the weather, and based on the changing environment, may be extremely beneficial in the High North going forward.

Next, I think as you have heard from all the panelists, the increase in communications capability across the board is required, and no more so than in the High North. So I think a strong look at how some additional fiber can be laid in to support the communications and bandwidth infrastructure in the High North is definitely warranted.

We have also heard a lot about the monitoring, and I think that is the key. Congressman Rice said—had mentioned about the lack of forecasting ability for the oceans. You go up to the High North, it is one-third. There is a reason why they say if you don't like the weather in Alaska, wait 5 minutes. It is because it is very unpredictable.

And, again, the more we monitor, the more sensors we put into the environment, the better those forecasts are going to be. And that has a direct effect in risk reduction for the folks that are out there trying to make a living on the ocean. And that is going to make us more efficient and a better economy, going forward.

Again, applaud the efforts of the unmanned side, both for the surface, the underwater, as well as the aerial. And, again, I look at the high-endurance, long—high-altitude, long-endurance UAVs to fill as a space-based gap filler, until we do get some additional satellites to cover some of those areas. And there is plenty of plat-

forms out there, trucks, that can fill that role right now to bring that capability to pass.

That is all I have. Thank you.

Mr. TERRILL. A couple of points I would like to make is, first, I think one activity this subcommittee could be involved in is giving a little more legs to the U.S. Coast Guard R&D facility to more closely interact with the Naval Research Enterprise and other Government agencies that are directly involved doing this whole MDA, maritime surveillance process. Coast Guard R&D would be a quick study to get up to speed on all those types of activities, and be able to leverage that at a significant cost savings to the taxpayer.

That would also include demonstration activities, so that we can work in a spiral development world, where we aren't placing large sums of resources into making bad mistakes. We can make bad mistakes with small investments, and learn lessons from those. So that would be one point I would make.

The other is what I talked about earlier with high-frequency radar, and how that is used for all the ocean science applications, as well as the MDA applications of them. And we are running into a little bit of a tragedy where every agency thinks the other guy is going to pick up the tab for it. Right now we have got NOAA stepping to the plate. They have been paying for 50 percent of that system, and it is used by a lot of other agencies. So getting some legs into those budgets that support those systems that are cutting across a lot of agencies—I don't know how to solve that problem, but that is one I will point out there.

And the last point would be that I think the long-term investment in ocean technology—specifically STEM—having science technology, engineering, mathematics efforts to support the future MDA workforce, future naval workforce, is only going to benefit this country. So I would encourage that. Thank you.

Mr. HUNTER. That is it for me this morning. Mr. Garamendi?

Mr. GARAMENDI. I want to thank the witnesses. Fascinating, very interesting. Very, very important.

It seems to me that there are a couple of things that—well, I have got a bunch of questions. I think I would like to submit them to you gentlemen, and you comment if you care to. We can't force you to, but I think it would be helpful. One of them has to do with all these UAVs and the security of them. Who can hack into them? What happens if they do, and suddenly the ship is headed for San Francisco, instead of San Diego? We looked at that when we were looking at an L&G terminal off the coast of Malibu, and what would happen if we missed the location of the ship. Anyway, I would like to look at those kinds of things.

Also, this issue has been raised, the chairman has been all over this forever and a day, and he ought to stay with it, and that is a lot of work is being done by independent researchers, university researchers, and the private sector, and attempting to be replicated by, in this case, the Coast Guard. The use of PortVision, wherein the Coast Guard would contract for that with PortVision, rather than building their own system. So we need to look at that across the board and to better utilize the private sector's work, and integrate that into the military.

I was taken by the testimony that you made. I asked about the integration of your Arctic program with the U.S. Navy and you said, “Not so much.”

We are out of time, so I am just going to say I am going to let it hang there. And when the opportunity arises to meet with the Navy and—I am going to ask them what they are doing in working with other organizations, and not invent-it-here mentality that exists everywhere—and I suspect in your own organizations also.

I will let it go at that. We will submit to you a series of questions. If you care to answer, it would be helpful to us. Thank you very much for the testimony.

Mr. HUNTER. I just want to say thanks for coming out. Thanks for coming out and kind of making—one of the reasons we do this is to simply raise the observation and raise awareness that you are out there, and that there is a blue economy, and there is this sector of the economy that is kind of—people don’t really pay attention to. And especially in southern California, people had no idea the impact, the good jobs, what it means for San Diego, you know, for maritime. So we are trying to just raise awareness.

You know, we don’t know if there is going to be a lot of funding for this type of stuff going forward. But what it means is, like Mr. Garamendi just said, it is not just the Coast Guard that could benefit, or the Navy that could benefit, or NOAA, or the weather folks. It is everybody, because everybody touches the ocean in some way, and maritime touches everybody.

And so, if there is a way to make sure that anybody that has got a stake in this game realizes that they have a stake in the game, kind of like the icebreaker for the Arctic, no one entity is going to pay for that. It is going to be a lot of agencies are probably going to have to help pay for that, if they see it as a priority, and that kind of goes along the entire section here of maritime technology.

So, I just want to say thanks for coming out. Thanks for talking with us. And thank you, witnesses. The subcommittee stands adjourned.

[Whereupon, at 11:06 a.m., the subcommittee was adjourned.]

Statement of the Honorable John Garamendi
House Subcommittee on Coast Guard and Maritime Transportation Hearing
"Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"

May 21, 2014

Mr. Chairman, thank you for scheduling this morning's hearing on new and emerging ocean technologies and their applications to advance maritime transportation and ocean science research in the United States.

This hearing is a perfect follow on to the two previous technology-based hearings convened by you earlier this Congress concerning, respectively, maritime domain awareness and the future of aids to navigation. I commend you for your interest in examining how technology is re-shaping maritime commerce. This is important.

From my perspective, however, two questions are the most pertinent to ask. First, is the United States aggressively maintaining its competitive edge in both basic and applied ocean research? And second, is the United States still the global leader in the development of new innovations in marine technologies?

The fact that I am even raising these questions should be alarming to everyone. Not too long ago, the U.S. was recognized as the uncontested world leader in scientific research and development, an edge that fueled the growth of our economy and led to an unparalleled legacy of scientific achievement in the 20th Century.

Now, the situation is quite different. Over the past thirty years Federal funding for basic ocean science and applied research has been reduced and is insufficient when compared with the level of funding invested in ocean science and engineering by our competitors abroad.

Some critics have claimed, in fact, that we have entered a new world order in scientific research, including ocean science and engineering. In this world, U.S. science will remain a leader, but other nations, especially China and India, will create an increasingly competitive environment which could have serious ramifications on U.S. national security and economic strength down the road.

What does this all mean for this morning's hearing? First, we need understand how these evolving circumstances are changing the scientific paradigm that has guided ocean science research in the United States for decades. We need to understand how the private sector and academic community are collaborating with Federal agencies, and we need to know how that collaboration can best be leveraged to advance innovation in ocean science and engineering.

The implications are huge, for both our stature as a science leader and our future as a global economic power. Thank you.

TELEDYNE
MARINE SYSTEMS
Everywhereyoulook™

Testimony on 21 May 2014 to the Subcommittee on Coast Guard and Maritime Transportation from Thomas W. Altshuler, Ph.D., Vice President and Group General Manager, Teledyne Marine Systems

The oceans are one of the most exciting economic opportunities of the 21st century. The global reliance on ocean resources and dependence on the marine environment will result in a continued growth in the so called "Blue Economy" worldwide. The United States has a unique leadership position in many aspects of the Blue Economy. The U.S. is the biggest single market, has a clear front runner position for advanced technology, and has an established role as a thought leader. With all these advantages, and the immense growth potential in the Marine markets, the Blue Economy is likely to provide U.S. businesses with strong returns over the next decade through both the domestic market and more importantly, international markets.

As a business leader for a group of companies within Teledyne Marine, called Teledyne Marine Systems, I have been privileged to participate in a portion of the growth of the marine segment of Teledyne Technologies, Incorporated Teledyne recognized the huge potential of the Blue Economy over a decade ago and has systematically grown its presence in the marine market. Currently, Teledyne Marine is a **growing** group of 13 established, well-reputed, undersea-technology companies whose collective size has expanded from $6M in 2000 to $600M in 2013, with approximately half of that revenue resulting from international sales of product. These companies have developed and introduced some of the most innovative technologies and products that have revolutionized diverse marine markets: from offshore to inshore and oceanographic to defense. Teledyne Marine has achieved this growth by a combination of acquisitions of technology leading companies and organic growth of those companies. This collective approach has resulted in strong, high technology job growth with direct and substantial impact on our local economies. Employing 2000 people, our marine companies provide high technology jobs nationwide from Cape Cod to San Diego, Seattle to Daytona Beach, and New Hampshire to the Gulf Coast. We have strong businesses in almost every pocket where technology innovation is driving the Blue Economy.

Our product portfolio spans a wide-range of capabilities. We provide undersea technologies including unmanned vehicles, measurement sensors, imaging and surveying systems, underwater communications systems, and underwater connectors. The benefits gained from the associated high-performance, reliable products have ranged from new scientific discoveries to operational efficiencies in very harsh environments worldwide.

As Teledyne Marine looks to the future, we see exciting opportunities for growth. Ours, and our market peers' current technologies, and technologies under development, will revolutionize how we understand and leverage the ocean. In the oceanographic arena, which is core to our understanding of the marine environment, the United States has a clear leadership position. Through programs such as the Integrated Oceanographic Observing Systems (IOOS), led by National Oceanographic and Atmospheric Administration (NOAA), the regional partnerships between Federal and State Governments, academic institutions, and the private sector have resulted in a leap-ahead understanding of the coastal marine environment, its influence on fisheries and the local economies in the U.S., and even weather forecasting. These regional partnerships facilitated by IOOS are viewed worldwide as a highly successful example of how to effectively leverage human talent and resources for costal marine studies, and have resulted in the growing export of marine technology to the international community.

Other key Federal programs include the Ocean Observatories Initiative (OOI), funded by the National Science Foundation, have resulted in an acceleration of advanced technology for both coastal and deep ocean observation. The fledgling success of the OOI has resulted in similar programs in Europe and even China. In all cases, U.S. technology will play a crucial role.

As with the Oceanographic market, the Defense/Security and Offshore arenas both fund the development of, and exploit, corporate internal research and development to ensure that Teledyne Marine and its peers can provide the most advanced technologies into the worldwide Blue Economy. With existing and emerging technologies, both the domestic and international markets will provide long term manufacturing job growth for our U.S. based businesses. As we compete with foreign developed technology, our technology advantages can be short-lived. Facilitating export of product is a key to sustained positive economic impact within the Blue Economy.

Overall, because of the partnership across Federal and State Governments, Academic and Not-For-Profit organizations, and privates business, the U.S. will lead the Blue Economy into the next decade.

Teledyne Marine Systems, 49 Edgerton Drive, North Falmouth, MA 02556, Phone - +1 508.563.1500

Subcommittee on Coast Guard and Maritime Transportation

Hearing on Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"

Wednesday, 21, 2014

Questions for the Record from Congressman John Garamendi

National Research Council 2011 Ocean Infrastructure Recommendations

In 2011, the Ocean Studies Board of the National Research Council released a report entitled, Critical Infrastructure for Ocean Research and Societal Needs in 2030. This forward-thinking report recognized that a coordinated national plan for making strategic investments in ocean infrastructure was necessary to maintain fundamental ocean science research over the next twenty years.

Furthermore, the report stated that a growing suite of infrastructure will be needed to address urgent societal issues, including tsunami detection, climate change, and offshore energy development and fisheries management. The report also offered several recommendations, notably the need to support continued innovation in ocean infrastructure development, and to engage allied disciplines and diverse fields to leverage technological developments outside oceanography.

From the report: "The global, internationally supported array of 3,000 Argo profiling floats (measuring temperature, salinity, and depth) is another critical component. Expansion of this network, both in terms of numbers and capabilities, will further enable study of the ocean's physical, biological, and chemical processes while providing essential data for assimilation into global models. Sensor capabilities for profiling floats are expanding (e.g., oxygen [O2], bio-optics, nitrates, rainfall rates, vertical current speeds), with additional sensors for pH, pCO2, and acoustics in development.

Extensive fleets of underwater gliders and autonomous underwater vehicles (AUVs) capable of operating in both expeditionary and long-duration modes, outfitted with a much broader suite of multidisciplinary, biofouling-resistant sensors will also be needed (e.g., physical [conductivity, temperature, and depth; stable salinity], chemical [O2, pH, nitrate], biological [acoustic, genomic], biogeochemical, and imagery [visual, acoustic]). AUVs will be capable of providing increased power and space for advanced sensors and more complex payloads. Moorings and ships with more capable sensors will provide local refinement needed for further quantification of processes measured and offer replenishment to AUVs operating in the vicinity.

The nested observation network together with embedded campaigns described above place a premium on widely shared data; this will achieve greater success if incentives are included for commercial operations in the coastal region to participate in data collection and use. Data management and data repositories are and will become increasingly important given the large data sets being collected for both global and regional studies,

including climatological, oceanographic, geological, chemical, and biological data. Many of the science questions and societal objectives will require adaptive sampling as well as event response capabilities"

Recommendation: Federal ocean agencies should establish and maintain a coordinated national strategic plan for critical shared ocean infrastructure investment, maintenance, and retirement. Such a plan should focus on trends in scientific needs and advances in technology, while taking into consideration life-cycle costs, efficient use, surge capacity for unforeseen events, and new opportunities or national needs. The plan should be based upon a set of known priorities and updated through periodic reviews.

Recommendation: Development, maintenance, or replacement of ocean research infrastructure assets should be prioritized based on (1) usefulness for addressing important science questions; (2) affordability, efficiency, and longevity; and (3) ability to contribute to other missions or applications. Such prioritization will maximize societal benefit for the nation.

Recommendation: National shared ocean research infrastructure should be reviewed on a regular basis (every 5-10 years) for responsiveness to evolving scientific needs, cost effectiveness, data accessibility and quality, timely delivery of services, and ease of use in order to ensure optimal federal investment across a full range of ocean science research and societal needs.

- ***To your knowledge, have Federal agencies embraced the recommendations made by the Ocean Studies Board? Has the effort been made to develop a coordinated national ocean infrastructure plan to help guide the private sector and ocean research community on where they should best focus their energies?***

The general themes in the report are widely accepted by Federal agencies. We are not aware of a specific effort to coordinate the ocean infrastructure plans of diverse agencies. Such efforts may be underway and moving slowly.

- ***Does this plan generally align well with the most important scientific questions and priorities of the ocean science and research communities?***

The report of the ocean studies board is generally well developed and conceived.

- ***In general, does this type of plan, one that identifies priorities and investment strategies for Federal agencies, help or hinder private sector firms? Can it function as a constraint on science and technology innovation?***

Typically products of the Ocean Studies Board and similar deliberative bodies are the product of significant work. They often become an amalgamation of all views, albeit a well developed one. The downside of such synthesis efforts is that they may lose some of the sharper more innovative concepts. If such plans and reports were the exclusive focus of investment by Federal agencies it might be a constraint on the private sector. But typically

there remain a diverse set of inputs from other commands and agencies. If the desire is to increase the availability of new technologies and innovation, it might be beneficial to encourage increased participation from the private sector on the Ocean Studies Board and similar bodies.

<u>National Integrated Ocean Observation System</u>

In 2009, building on the initiative of the ocean science community, the Congress passed legislation providing an organic authority for the establishment, administration and operation of a National Integrated Ocean Observation System, or IOOS. Since then, IOOS has continued to mature and expand its monitoring, observation and data sharing capabilities. Most important, IOOS has more than demonstrated its versatility and value providing information vital to Federal responses to recent disasters, including Hurricane Sandy and the DEEPWATER HORIZON oil spill, and to improving the accuracy and efficiency of Coast Guard Search and Rescue operations. Most witnesses at the hearing spoke positively about the multiple benefits now available through investments made in IOOS infrastructure.

- ***In your opinion, how can we best support IOOS to ensure the continued build out and expansion of the planned IOOS architecture, and the further integration of IOOS data into basic and applied ocean science research?***

IOOS is a National program designed to bring together multiple Federal agencies. It is led by NOAA and the Integrated Ocean Observing Committee (IOOC). While this structure is appropriate the diverse requirements of the program it can challenge the IOOS Program's ability to fulfill its designated leadership function. Elevating and advancing the IOOS program in the eyes of the constituent agencies, especially NOAA and the IOOC would be helpful.

- ***How can we best ensure that the private sector is able to continue to develop innovative products and services derived from observation data gathered by IOOS infrastructure?***

A challenge identified by the IOOC includes the prohibition on "mixing money" in ways that might yield increased public/private partnerships or improved interagency coordination. These funding rules are ensconced in Federal law and would require significant legislative action to change. But the IOOS Federal Advisory Committee is currently exploring the issue of improved public/private partnerships in IOOS. It might be beneficial to review the minutes and recommendations of the IOOS Federal Advisory Committee.

- ***Have the eleven certified IOOS regional associations performed as expected? If not, what recommendations might you provide to enhance the capabilities of the regional associations?***

It is our impression that the regional associations have made excellent progress, especially in light of the funding constraints. Several have established themselves as stand-alone not for profit organizations. This allows them to explore new approaches to fulfilling their mission.

- ***To your knowledge, has any analysis been completed to determine the level of economic activity leveraged by Federal and non-Federal investments in IOOS infrastructure? Should authorized funding levels for IOOS be increased?***

We are not aware of explicit studies on this question. But our impression is that the IOOS program delivers results out of proportion to its funding levels. The IOOS independent cost estimate provides significant detail on what a fully funded IOOS level might be. We note that such a fully developed IOOS might not necessarily be dependent entirely upon Federal funds. But given the disparity between that cost estimate and the current IOOS budget it would appear there is room for consideration of additional IOOS funding.

Need to Maintain STEM Funding

As I mentioned in my opening remarks at the hearing, the United States remains the world's leader in science but its preeminence is now being challenged aggressively by international competitors, notably China and India. Some people believe that this circumstance is directly related to insufficient funds being invested to support STEM education in the United States.

- ***From the standpoint of marine engineering and technology development, how important is it for the United States to maintain its investments in STEM education?***
  The investments in STEM are seen as a very positive step towards reinvigorating technological careers. STEM has opened up dialog between local business, schools, and colleges that did not exist in the past. Local businesses now actively participate in reviewing college curriculum choices in an effort to graduate qualified future employees. Scientists and engineers support high schools advising on student projects and making presentations promoting local research.
- ***Is it practical to believe that the United States will be able to maintain its competitive edge against other global competitors if we fail to invest sufficiently in STEM education?***
  There is a high demand for talented engineers in the workplace. Unfortunately the maritime business may be located in remote, less densely population areas. As a result, the pool of engineering talent may be negatively affected. Investing in STEM at the local level generates interest not only in technology, but also local business. Local students who travel to distance schools have a higher chance of returning after a STEM education.
- ***Regarding maritime education, how important is it for the Congress to continue to provide financial support for the U.S. Merchant Marine Academy and the six state maritime academies? Is the type of maritime training made available through these institutions a necessity for future ocean science and research?***
  The local maritime colleges not only provide future merchant marines but also a location for ocean based STEM curricula such as ROV (Remotely Operated Vehicle) competitions. They are seen as a positive part of the local community. Many graduates have a foundation that leads to careers not only in technology but other associated fields.

Recommendations for Better Coordination between Public/Private Sectors

In general, ocean science research and engineering has been predominantly a collaborative enterprise between a select few Federal agencies, notably the U.S. Navy, the National Science Foundation, and the National Oceanic and Atmospheric Administration, with universities and private sector contractors. And while this model has produced substantial scientific achievements, I get the sense that more could be done to improve coordination, to better leverage Federal investments, to address emerging ocean science objectives, and to provide new markets for ocean technologies.

- ***What recommendations can you offer to improve the coordination of Federal agencies, both among themselves and with their extramural partners in the private sector and university community?***

There are several not-for-profit societies, such as the Marine Technology Society, the can act as a facilitator for coordination across the various agencies and non-Governmental organizations. By encouraging routine industry engagement by the different Government agencies, as well as participation in the array of technical conferences within the marine community, the opportunity to develop interactions and thought collaborations should be facilitated.

- ***What can be done to improve the Coast Guard's interaction and collaboration with the ocean research and Blue Tech communities to address the Coast Guard's operational mission needs?***

The USCG is not usually perceived a major player in the marine science and technology (S&T) sectors. The commercial and academic organizations engaged in R&D might benefit from more aggressive outreach by the USCG, especially the USCG R&D Center.

- ***Should the Coast Guard work more closely with the Office of Naval Research or Oceanographer of the Navy in areas of common interest, particularly in the littorals?***

There is certainly room for increased collaboration between ONR/NAVO and the USCG. Shared investments and approaches to maritime domain awareness and employment of unmanned systems such as AUVs are viable areas of collaboration. In addition, if these agencies could establish common requirements it would be of benefit to the commercial and academic R&D sectors. A clearly synchronized set of R&D requirements will facilitate appropriate internal R&D investments by commercial entities

UUV and UAV Security

Underwater Unmanned Vehicles (UUVs) and Underwater Autonomous Vehicles (UAVs) are assuming a greater role as a tool for ocean research. Additionally, greater attention is now being devoted to investigating the potential use of UUVs and UAVs for other purposes, including for Maritime Domain Awareness. Some questions have come up concerning the both the cybersecurity and physical security of these assets once deployed in the marine environment, especially whether these assets might be co-opted, confiscated or otherwise compromised by our enemies.

- ***What are your views on the security profile of UUVs and UAVs in the marine environment? What can be done to prevent hackers from accessing and controlling these vehicles?***

The approaches to security for UUVs and UAVs (also referred to as Autonomous Underwater Vehicles (AUVs)) are based on the unique way the vehicles function. Typically UUVs and AUVs are disconnected from the network during a significant portion of an operation. It is only during mission updates and data downloads that the vehicles are truly vulnerable because they are exposed to a network. Underwater, the vehicles are typically linked via low data rate acoustic communications. This low level of high-speed network connectivity reduces the risk of hacking, and provides an opportunity for a robust security infrastructure. Very little data and control is executed in real time, thus increasing the opportunity for robust security.

- ***What type of risk does this create for ocean science researchers or other maritime operators whose dependence on these assets for data gathering, communication, surveillance and other activities is projected to grow dramatically in the future?***

The largest vulnerability is not access and control of the vehicle, but integrity of the data collected by the UUVs and AUVs. Corruption of the data could influence operational decisions by the user. In addition, there are longer term influences that could include resource allocation and policy decisions.

Absence of GPS Back–up System

Global Positioning Satellites (GPS) enable researchers and engineers to communicate with UUVs and UAVs and enable these assets to operate independently and in extremely remote environments. Since 1995, the space-based GPS navigation system has become indispensable to national and economic security. Concerns have been raised that there is no available backup capability for comparable timing and location information, and that this gap is a significant liability for national defense, transportation systems, and ocean science research.

- ***How disruptive would the loss of GPS communication be for the operations and activities of your organization?***

Most of our vehicle use GPS for positioning. This is required to permit accurate mapping, and self-location of the vehicles. Loss of GPS would severally limit the value of the data collected and could increase the loss probability for the vehicles at sea.

- ***What communication and timing and location information options would be available to you in the absence of GPS?***

AUVs typically use line of sight RF or Iridium satellite communication as a longer range data link. GPS is used only for positioning. In the absence of GPS, the positioning information for all operations other than those close to shore would be significantly compromised. There is no other simple way to provide high accuracy positioning without employing GPS as a fiducial.

- ***Should the Federal Government develop some kind of land-based GPS back-up system?***

A land-based GPS back-up could have value, but only for near shore operations. In order to operate in the open ocean, an analogues system to GPS is necessary.

Written Testimony of Mr. Charles Benton for a House Committee hearing on "Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Doman Awareness and Response Capability".

Presented May 21, 2014

2253 Rayburn House Office Building

Chairman Hunter and distinguished Members of the Committee,

Thank you for the opportunity to appear before you to testify on the subject of Small Vessel Safety and Security at this important hearing. I appreciate and welcome the Committee's continued focus on this subject.

Vessel tracking enables collision avoidance, makes more efficient use of our waterways possible, and enhances maritime security and response. The Automatic Identification System (AIS) developed in the 1970's is the primary vessel tracking capability for large ships. This capability has been extremely successful and is used in a broad range of operational settings. However, the reality is that the costs and infrastructure of AIS result in less than 1% of all vessels actually using it.

There is a long identified need to better support small vessel operations through enhanced identification and tracking capabilities. In 2010, the the Department of Homeland Security issued a Small Vessel Security Strategy[1] that outlines many issues relating to this.

In 2010 the Department of Homeland Security S&T Directorate, Borders and Maritime Division issued a Small Business Innovation Research Program Topic looking for innovative new "Small Vessel Identification and Tracking Technologies". My company responded with a proposal titled "Smart Chart AIS", and set forth the concept that since virtually all small vessel operators also had smart phones, a surrogate AIS capability could be developed that took advantage of these already present systems.

This resulted in development of the Smart Chart AIS app that is distributed for free to the public. Features in Smart Chart AIS include: NOAA charts, weather radar, cruising guide information, social network functionality, Augmented Reality capability, and most importantly, surrogate AIS capability for small vessels, referred to as AIS-i.

AIS-i is a new AIS protocol we developed for use over the wireless internet. We are putting this protocol into the open domain, and have engineered it so that any company can integrate the protocols into their equipment. The intent is to enable all small vessels to use AIS-i for free or at very low cost.

---

[1] https://www.dhs.gov/small-vessel-security-strategy

A recent conference at the California Maritime Academy, titled "e-Navigation Underway". e-Navigation is defined as:

> The harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment.

I presented a paper titled "AIS-i – Supporting the Recreational Boating Community over Wireless Internet", which was enthusiastically received. Attendees included senior government and industry personnel from around the world. This led to an invitation by the Radio Technical Commission for Maritime Services (or RTCM) to make a presentation at their annual technical meeting. RTCM is an international body that creates standards and documentation that are referenced by the International Electronics Commission and the UN's International Maritime Organization in establishing, and sometimes mandating, performance standards.

An outcome of the meeting was a unanimous committee vote to have two Special Committees evaluate and report on having AIS-i formally reviewed and incorporated into the international standards process. This is the first step in a process leading to AIS-i protocols being adopted on a global basis.

The protocols and service that have emerged from this project are gaining national and international recognition as an appropriate and clearly needed solution that will enhance maritime safety and security. The project is rapidly transitioning from an R&D phase to a transitional phase in which standards will be finalized and formally adopted. Continued support for these efforts will ensure that Homeland Security interests are addressed and that the US will provide the leadership needed to enhance the safety and security of the 99% of the maritime community that small vessels represent.

Thank you again for your interest and focus on this important subject.

For further information contact Chuck Benton at [redacted] or cbenton@tsinc.com

Statement of

Casey Moore
President
Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005 USA
(425) 643 9866

Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability

Before the

Subcommittee of Coast Guard and Maritime Transportation
Committee on Transportation and Infrastructure US House of Representatives
Washington, DC

May 21, 2014

On behalf of Seabird-Scientific I wish to thank Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee for the opportunity to address the committee regarding the roles and impact that modern ocean observing holds for our country's public interests and maritime economy. I am Casey Moore, President of Sea-Bird Scientific. In being here today, I represent the over 200 scientists, engineers, trained technical, marketing and sales, and support associates that comprise our company. I also speak in support of other businesses, researchers and resource managers throughout our nation engaged in development, operation, and application of our ocean observing capabilities.

Sea-Bird Scientific develops and manufactures oceanographic sensors, systems and deployment platforms for the Oceanographic Science and Monitoring communities. Our products are used around the world with well over 50% of our revenues from international sales. While our products now hold global reach, our technical capabilities emerge directly from collaboration and partnership with US and Canadian academic research institutions, science agencies, and naval research and operations organizations. Our core capabilities are in development and manufacture of sensors for measuring physical, biological and chemical properties throughout the ocean. These sensors determine temperature, salinity, dissolved oxygen, phytoplankton abundance, nutrient concentrations, pH and numerous other chemical and biological parameters. As ocean technologies these products differentiate themselves by being able to provide accurate, stable and precise measurements, often unattended for months to years, in very challenging marine environments. Sea-Bird Scientific instruments are used in numerous applications. These range from the global scale such as understanding ocean circulation and global heat transport budgets, to local environments where ocean acidification and hypoxia threaten critical resources and people's livelihoods.

Ocean observations are not a new concept in supporting maritime transportation, public health and safety, and environmental protection. For example, sea-state parameters, such as wave height and tides, have been use by the Coast Guard and maritime industry for years. What is new are the technology advancements in sensors and communications that allow for detailed observations from remote areas to be used to solve immediate problems. Network capabilities currently give responders, operators and researchers the ability to pull together data from remote sensing tools such as satellites and HF radar and autonomous platforms equipped with water property sensors, fundamentally changing the game:

- Water property parameters from fixed assets such as buoys and tide gauges provide new information for real-time use and critical decision making by agencies and industries;
- Costly and limited discreet ship-based operations have been augmented and replaced by robotic autonomous samplers for the surface and vertical water column;

- HF radars provide near-continuous sea state data along our coasts;
- Remote imagery from satellites effectively map physical, biological and chemical processes across the surface of the ocean.

Using these technologies, local and regional ocean observing systems have teamed with federal and state agencies, academic researchers and public stakeholders to form a nationally scaled Integrated Ocean Observing System (IOOS). IOOS serves an increasingly important role in managing the observing infrastructure, and uses the scientific information derived from the observing networks to supply application products and information content in support of its stakeholders – maritime based industries, tribes, recreational boater and fishers, and communities.

Water property sensors play integral roles in these emerging observing capabilities and are used for a broadening array of applications. Developing and established uses include:

- Ocean health and biodiversity monitoring to drive regulation and advanced management of fisheries, recreation, and coastal habitat;
- HABs monitoring and warning systems for early response to reduce negative human-health and commercial impacts;
- Determining roles, impacts and forecasting for response to long term weather pattern prediction;
- Forecasting impacts of storm events for response preparations;
- Monitoring major ocean pollution events for early response, mitigation and understanding impacts;
- Maintaining strategic economic zone interests.

These examples not only demonstrate the growing utility of these measurements but also point to the public's need for them. To be clear the investments in these tools, and in ocean observing systems, are in large measure managed through the public sector. While industries such as oil and gas sector have invested significantly in developing ocean observing, it is only through the sponsorship of federal science and defense agencies that our capabilities lie where they do today. This sponsorship represents significant investment, which has driven even larger returns – both economic, and in basic protection of human populations living on our coasts and using our oceans. I pose to the committee two examples of how ocean observing efforts have impacted recent events. With these I attempt to show, not only the role of our industry and the relevance of how water property and other observing technologies were applied, but also point to critical gaps that remain and require further leadership, sponsorship and investment.

In late 2012, Hurricane Sandy exacted heavy damage on the eastern seaboard of the US. The storm and resulting storm surge are a well-documented saga. Perhaps less publicized was how damages and possible loss of life were averted through use of regional IOOS assets. In a

summary narrative supplied by the Marine Technology Society to the National Ocean Service office at NOAA, IOOS buoys and moorings specifically enabled the following actions.

- Regional transport authorities used IOOS assets to indicate the potential storm track. Merchant shipping interests diverted container vessels containing approximately 23000 TEUs, from NY and NJ destinations to other safe ports. Accounting for two ports alone, actions resulted savings estimated at 6 billion USD.
- The Navy moved 80 ships out of the storms reach from its Hampton Road facility. While this effort cost over $10 million to execute, based upon previous major storm events at the facility, estimated savings from avoided pier and ship damages were approximately $500 million.
- In Hoboken, New Jersey, alone, over 1700 local businesses and homes were destroyed or damaged from flooding by the storm surge. While the property damage resulting from this event was enormous, given foresight from data and forecasting information, the Hoboken mayor avoided a much larger disaster by ordering timely evacuation of over 34000 people living on first floors and in basements in the city.

While these events in many respects validated the utility for ocean monitoring, they belie an important point. We could have done better. Current observing capabilities along the east coast are only a fraction of those envisioned by the IOOS. In this case a denser installation base of buoys and in-water monitoring aspects could have further reduced storm track and intensity uncertainty and further enabled response teams to reduce economic and human tolls from the hurricane. As one specific example higher spatial resolution vertical sampling of the ocean temperature would have provided greater accuracy in determining the storm intensity upon reaching landfall. This could save millions in preparations and better enabled response efforts.

The 2010 BP oil spill from the Macondo well points both to the need of broader ocean observing infrastructure and to the emerging role that water property measurements might play in support of regulation and response efforts. This incident is one of the more well publicized pollution events in recent history. The immediate aftermath of the rupture resulted in a flurry of episodic observing efforts to determine the fate and impact of the oil released into the environment. New and existing sensing technologies for tracking the oil itself were employed, along with a wide array of supporting environmental measurements to monitor ocean health after the spill. Significant data was gathered by numerous research organizations, agencies, and businesses assigned to address the spill. This information definitely helped responding agencies provide scope and focus during initial response, but in light of the scope and cost of the efforts, it held only limited impact in providing actionable information in determining dispersion and fate to help manage response. Existing observing infrastructure was extremely limited, especially through the deeper water column. Moreover data and some methods for the oil detection were unproven, and not qualified. Finally the data coming from the various ad hoc efforts were difficult to assimilate since there was no central data management and control in place at the onset.

After the spill, the prospect of funds supplied by BP prompted the shoreline states of the Gulf of Mexico to fund science centers that will determine how best to deploy and use ocean and coastal observing systems in the future. In addition the Coast Guard and NOAA invested in subsequent studies for oil detection methodologies. These studies are ongoing, and show that many technologies deployed during the aftermath of the crises were effective and could be used in various ways to better understand the fate of oil within the water. This has since allowed scientists to better understand and qualify data acquired during the spill and in establishing best practices for the future. Finally, Gulf of Mexico Research Initiative (GoMRI) funding, resulting from early settlements, continues to support academic, state government and business consortiums. These efforts may lead to various new sensor technologies and observing applications.

While these efforts will benefit scientific understanding, four years after the spill, little or no funding has been released to the State Centers or to the regional IOOS organizations and partners to expand ocean observing efforts in the Gulf. The potential for a similar pollution event would, in and of itself, justify broader deployment of fixed and autonomous assets for ongoing monitoring. The Gulf also holds significant notoriety for storms and HAB events. It holds some of the US' major fisheries, and is a major transportation conduit into and out of our territorial waters. This is a case in which there is not only a clear and timely need, but with vast dollars in play, as a result of subsequent and ongoing settlement processes, there is a potential path for funding. Many suffered from the BP spill – coastal habitats and the human eco system of businesses and communities along the coast were all hurt. I do not presume that dollars supplied in settlement should not go in support of restoring these communities. I do suggest that a small fraction of settlement monies in expanding ocean observing capacity will help everyone in these communities and will serve them many times over in helping them better respond to, mitigate and manage future challenges.

At a national level a fully capable ocean observing network requires substantial investment. Independent studies provided to IOOS show that costs for a full build-out and operation of national ocean observing network, including, satellite and remote platforms, in water assets, needed sensor development data management and control, and operations and maintenance, will exceed $3 billion annual investment. While this is a large number it is important to remember that approximately 45% of our country's GDP is now concentrated into coastal regions. Economic and human impacts of ocean events and our need to effectively regulate and respond will only increase. One common model we use in describing the future of our industry, is that we see ocean observing networks and systems eventually growing into an analog of our national weather network. This analogy is apt. Effective monitoring of the ocean extends our ability to gain greater acuity in understanding long term weather patterns, or climate. With greater forecasts we can better manage resources to mitigate and manage, as opposed to simply falling victim to changing conditions. This will not only benefit the fisher in Oregon, but also the farmer in Kansas. With this thought in mind I contend that 50 years ago we likely had no idea how deeply ingrained our national weather network would become so entwined in our lives. In an era in which we have unprecedented capacity and know-how to

assimilate and manage data from our environment, is there any reason to believe that that we will not benefit from similar expansion of our ocean observing capabilities?

I once again wish to thank the Chairman, Ranking Member, and committee for the opportunity to provide testimony in this important matter.

Subcommittee on Coast Guard and Maritime Transportation

Hearing on Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"

Wednesday, 21, 2014

Questions for the Record from Congressman John Garamendi

<u>National Research Council 2011 Ocean Infrastructure Recommendations</u>

In 2011, the Ocean Studies Board of the National Research Council released a report entitled, Critical Infrastructure for Ocean Research and Societal Needs in 2030. This forward-thinking report recognized that a coordinated national plan for making strategic investments in ocean infrastructure was necessary to maintain fundamental ocean science research over the next twenty years.

Furthermore, the report stated that a growing suite of infrastructure will be needed to address urgent societal issues, including tsunami detection, climate change, and offshore energy development and fisheries management. The report also offered several recommendations, notably the need to support continued innovation in ocean infrastructure development, and to engage allied disciplines and diverse fields to leverage technological developments outside oceanography.

- ***To your knowledge, have Federal agencies embraced the recommendations made by the Ocean Studies Board? Has the effort been made to develop a coordinated national ocean infrastructure plan to help guide the private sector and ocean research community on where they should best focus their energies?***

  CM: The NSF sponsored Ocean Observing Initiative (OOI) and other, more nascent, infrastructure planning efforts embrace the spirit of the recommendations made within the NRC report. The OOI program has dominated NSF funding to the ocean research community in the past few years. Many scientists in the US, claim that the OOI funding placed the proverbial eggs in a single basket for US sponsored ocean research, thus limiting funding for many other innovation opportunities and potential discoveries. This controversy around supporting large science versus small is not unique, but certainly proves a disruptor for the academic oceanographic community.

  OOI is into its fourth year, and the build-up of infrastructure is well underway. Organizational challenges facing NSF and the involved academic institutions are largely overcome and many significant innovations are beginning to emerge. However, one problem not resolved is how will funding dollars displaced into this program once again become focused upon other researchers and institutions within the oceanographic

community. In other budget environments OOI might have appeared less controversial. As it is, many research programs around the country definitely suffered.

- ***Does this plan generally align well with the most important scientific questions and priorities of the ocean science and research communities?***

  CM: The NRC plan is very comprehensive, and if fully implemented, would potentially serve scientists in addressing key societal needs. It is important to note that success will also rely upon effective research funding and education efforts.

- ***In general, does this type of plan, one that identifies priorities and investment strategies for Federal agencies, help or hinder private sector firms? Can it function as a constraint on science and technology innovation?***

  CM: I support comprehensive planning efforts such as the NRC document, and feel that they aid both the private and public sectors by setting a broad agenda. How effective these plans are, often depends upon public and private support for implementation. The plan is comprehensive and addresses a broad set of needs. I'm not sure whether it provides clear priorities in how we manage implementation and improvement of our observing infrastructure in a limited funding environment. Implicit within the NRC text is the notion of enabling scientists not only to monitor but to discover. As long as this context isn't lost in future stages of implementation, it will not constrain innovation.

<u>National Integrated Ocean Observation System</u>

In 2009, building on the initiative of the ocean science community, the Congress passed legislation providing an organic authority for the establishment, administration and operation of a National Integrated Ocean Observation System, or IOOS. Since then, IOOS has continued to mature and expand its monitoring, observation and data sharing capabilities. Most important, IOOS has more than demonstrated its versatility and value providing information vital to Federal responses to recent disasters, including Hurricane Sandy and the DEEPWATER HORIZON oil spill, and to improving the accuracy and efficiency of Coast Guard Search and Rescue operations. Most witnesses at the hearing spoke positively about the multiple benefits now available through investments made in IOOS infrastructure.

- ***In your opinion, how can we best support IOOS to ensure the continued build out and expansion of the planned IOOS architecture, and the further integration of IOOS data into basic and applied ocean science research?***

  CM: Beyond building expanded infrastructure and monitoring missions, IOOS will best serve our national interests through developing public – private partnerships in IOOS implementation. As an example, NOAA recently made available it vast archive of oceanographic data for potential public-private partnering in application use. Applications arising through private sector that may benefit or enhance IOOS value, should be rolled in and adopted when feasible. Similarly IOOS recommendations for SBIRs solicitations into partnering agencies could be entertained. Finally I strongly support continuation and expansion of the National Oceanographic Partnership Program (NOPP), using IOOS oriented topics.

- ***How can we best ensure that the private sector is able to continue to develop innovative products and services derived from observation data gathered by IOOS infrastructure?***

  CM: See above.

- ***Have the eleven certified IOOS regional associations performed as expected? If not, what recommendations might you provide to enhance the capabilities of the regional associations?***

  CM: I do not hold experience in working with all the IOOS regional associations. In general I think they have served two primary roles.

  1. They operate as research consortiums in maintaining and expanding regional resources – in this capacity they have been reduced to limited capacity beyond primary PIs and connected institutional based infrastructure due to funding;

2. They serve as a connection resource among government managers, academic researchers and the community of citizens and businesses in which they operate – In this capacity they, on whole, have excelled.

- ***To your knowledge, has any analysis been completed to determine the level of economic activity leveraged by Federal and non-Federal investments in IOOS infrastructure? Should authorized funding levels for IOOS be increased?***

CM: I am unaware of any comprehensive outside studies on economic leverage/impact from IOOS. IOOS has provided reports on its own behalf on occasions. The summary that was requested from the Marine Technology Society, reviewing use of IOOS related monitoring during hurricane Sandy, was an example that chronicled impact from a specific event. Regional sites hold numerous anecdotal cases within their websites. As a inverse example, consider the massive litigation and uncertainty surrounding the aftermath of the BP Gulf Spill. How might this current scenario have been impacted through broader monitoring infrastructure in the Gulf?

Need to Maintain STEM Funding

As I mentioned in my opening remarks at the hearing, the United States remains the world's leader in science but its preeminence is now being challenged aggressively by international competitors, notably China and India. Some people believe that this circumstance is directly related to insufficient funds being invested to support STEM education in the United States.

- ***From the standpoint of marine engineering and technology development, how important is it for the United States to maintain its investments in STEM education?***

CM: Major emerging economies see ocean observing infrastructure as part of a strategic imperative to establish and maintain dominion within their EZs and beyond. STEM education is inherent in their efforts and is deeply encouraged and sponsored. Within the US we have perhaps leaned towards considering ocean observing as an academic pursuit and a funding luxury of sorts. By any measure we find ourselves in a dangerous position by allowing our advantage to erode

- ***Is it practical to believe that the United States will be able to maintain its competitive edge against other global competitors if we fail to invest sufficiently in STEM education?***

No.

- ***Regarding maritime education, how important is it for the Congress to continue to provide financial support for the U.S. Merchant Marine Academy and the six state maritime academies? Is the type of maritime training made available through these institutions a necessity for future ocean science and research?***

CM: The above institutions along with the Sea Grant programs, the major NOAA and Naval labs, and the other major oceanographic schools and labs, must be supported and fostered with the goal of providing the very best education and high caliber ST research.

Recommendations for Better Coordination between Public/Private Sectors

In general, ocean science research and engineering has been predominantly a collaborative enterprise between a select few Federal agencies, notably the U.S. Navy, the National Science Foundation, and the National Oceanic and Atmospheric Administration, with universities and private sector contractors. And while this model has produced substantial scientific achievements, I get the sense that more could be done to improve coordination, to better leverage Federal investments, to address emerging ocean science objectives, and to provide new markets for ocean technologies.

- ***What recommendations can you offer to improve the coordination of Federal agencies, both among themselves and with their extramural partners in the private sector and university community?***

  CM: While structured programs such as National Oceanographic Partnership Program may offer some avenue for better coordination among these groups, I do not feel qualified to address the nuances of interagency coordination.

- ***What can be done to improve the Coast Guard's interaction and collaboration with the ocean research and Blue Tech communities to address the Coast Guard's operational mission needs?***

  CM: In some programs (eg. oil detection, ballast water) we are unclear of the Coast Guard mandate, and it seems to shift. It's unclear whether this results from gaps in communication, changes in priority, or shifts in federal policy.

- ***Should the Coast Guard work more closely with the Office of Naval Research or Oceanographer of the Navy in areas of common interest, particularly in the littorals?***

  CM: While this might be a good idea I'm afraid Coast Guard participation with these organizations would entail a certain relegation of priorities and approaches. There is always a trade-off in this approach.

UUV and UAV Security

Underwater Unmanned Vehicles (UUVs) and Underwater Autonomous Vehicles (UAVs) are assuming a greater role as a tool for ocean research. Additionally, greater attention is now being devoted to investigating the potential use of UUVs and UAVs for other purposes, including for Maritime Domain Awareness. Some questions have come up concerning the both the cybersecurity and physical security of these assets once deployed in the marine environment, especially whether these assets might be co-opted, confiscated or otherwise compromised by our enemies.

- ***What are your views on the security profile of UUVs and UAVs in the marine environment? What can be done to prevent hackers from accessing and controlling these vehicles?***

  CM: As with components within the emerging 'internet of things', cyber security associated with a network of UAVs/UUVs is a growing risk. Practically speaking this risk scales with vehicle and applications. Profiling drifters in the Pacific gyre pose relative small risk where as propelled UAVs deployed in or around ports and harbors provide a potentially high-risk profile from both cyber vulnerability and direct deployment from unfriendly forces. This points to a need for a new area of ST, education, and operations within the marine technology sector.

- ***What type of risk does this create for ocean science researchers or other maritime operators whose dependence on these assets for data gathering, communication, surveillance and other activities is projected to grow dramatically in the future?***

  CM: The most significant risks lie with our backbone components (eg. intercontinental fiber trunk lines, irridium network, GPS, DMAC infrastructure). Protection of these assets are national security concerns.

Absence of GPS Back-up System

Global Positioning Satellites (GPS) enable researchers and engineers to communicate with UUVs and UAVs and enable these assets to operate independently and in extremely remote environments. Since 1995, the space-based GPS navigation system has become indispensable to national and economic security. Concerns have been raised that there is no available backup capability for comparable timing and location information, and that this gap is a significant liability for national defense, transportation systems, and ocean science research.

- ***How disruptive would the loss of GPS communication be for the operations and activities of your organization?***

CM: Loss of GPS is a significant disruptor for all mobile platforms. Buoys can use local time-keeping, but some service may be compromised.

- ***What communication and timing and location information options would be available to you in the absence of GPS?***

- ***Should the Federal Government develop some kind of land-based GPS back-up system?***

CM: Both land and sea emergency positioning systems may now be technically feasible.

WRITTEN TESTIMONY OF

Dean Rosenberg
CEO, PortVision
A division of AIRSIS Inc.
San Diego, CA

BEFORE THE UNITED STATE HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

USING NEW OCEAN TECHNOLOGIES: PROMOTING EFFICIENT MARITME TRANSPORTATION AND IMPROVING MARITIME DOMAIN AWARENESS AND RESPONSE CAPABILITY

May 21, 2014
Washington, D.C.

Good morning and thank you Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee.

My name is Dean Rosenberg and I am the CEO of AIRSIS, a software technology company focused on the energy and transportation industries. Our PortVision division provides patented tools and technologies to increase maritime domain awareness and improve waterway safety, security, and efficiency. PortVision maintains a global network of VHF receivers that detect the collision-avoidance signals, also known as "Automatic Identification System" or AIS signals, transmitted by vessels around the world.

AIS transponder use by vessels larger than 300 gross tons, or 65 feet in the US, has been mandated by the US Coast Guard and the International Maritime Organization since 2005. Its original purpose was collision-avoidance at sea. However, shortly after AIS went into widespread use, we realized that the same data used aboard vessels could also provide significant value to shore-side personnel who needed to solve business problems. So, in 2006, PortVision was born, leveraging federally mandated technology and repurposing it to drive additional benefits across the maritime industry.

Now, in 2014, our PortVision AIS network processes over 50 million real-time vessel position reports each day, and we maintain a data warehouse of over 40 billion arrival, departure, and individual vessel movements dating back to 2006. To put this another way, during every second of my testimony today, PortVision is processing another 500 real-time vessel positions from around the world. Our commercial and government customers use this data to improve many types of operations, whether it be scheduling of vessels at an oil refinery, supporting an incident response operation, providing post-mortem compliance, legal, or training support, or supporting homeland security and law enforcement activities. There are over 3,000 PortVision users leveraging AIS for these and other valuable purposes, including vessel operators, marine terminals, government agencies, and every major oil company.

You can think of our network as a commercial version of the Coast Guard's National AIS ("NAIS") initiative. However, while the NAIS initiative is focused primarily on aggregating AIS data around the United States and its territories, we have extended real-time vessel detection globally through both terrestrial and satellite AIS receivers. Additionally, the NAIS initiative is primarily focused on AIS

data acquisition for use in VTS and related operational environments, whereas PortVision is focused on analysis and harvesting of that data to drive business intelligence that improves visibility, efficiency and decision-making in the maritime domain. In general, our observation is that current government systems appear to be good at collecting and displaying real-time data, but not aggregating and making it broadly accessible to field personnel who must clearly understand waterway utilization in order to carry out their mission objectives.

AIS continues to grow in value. We participate in numerous maritime industry groups around the country that rely on our data and expertise, and we are regularly called upon to provide AIS data and testimony associated with key incidents such as the Deepwater Horizon oil spill, major hurricane and weather events, and numerous compliance and law enforcement activities.

AIS is also helping the maritime industry accommodate today's surge of Gulf traffic, including vessels transporting crude oil shipments from new finds in the Dakotas, West Texas, and other locations. PortVision is a key enabler in this new and evolving chapter in our nation's energy evolution.

Another promising development is the use of AIS in pipeline, bridge, and offshore asset protection. PortVision partnered with CAMO – an industry trade association of Coastal and Marine Operators on a system to proactively notify vessels and pipeline operators when there is imminent risk that a vessel might damage pipeline infrastructure. Over the last two decades there has been over $100 million in property damage and over 25 fatalities associated with coastal and marine pipeline incidents. Our project with CAMO has received Coast Guard approval, and FCC approval is pending.

Still another AIS application is identifying bad actors and driving regulatory compliance. For example, PortVision has participated with the Offshore Marine Service Association to identify and report Jones Act violators, while individual port authorities use PortVision to enforce speed and emission reduction initiatives. Other federal government customers use PortVision data and services to support homeland security and intelligence operations.

These value-added AIS benefits are only possible if carriers transmit a persistent AIS signal with accurate data. We know of no uniform enforcement or educational campaign by the US Coast Guard to ensure that carriers comply. Some regional VTS offices are vigilant about compliance, while other regions have less active oversight. I urge the Subcommittee to ensure that all vessels required to transmit AIS maintain a consistent, uninterrupted, and accurate AIS transmission to ensure that these valuable AIS technology initiatives can continue.

Finally, I seek the Subcommittee's support in encouraging federal agencies to look to the commercial sector and small business to help execute their maritime domain awareness initiatives. Companies like ours provide proven, valuable services at very low cost, and yet less than 10 percent of our customer base is government users. Commercial offerings like PortVision are often overlooked in favor of "re-inventing the wheel" through government-funded "build-versus-buy" initiatives. This "not invented here" culture can put up barriers to government adoption of proven and widely deployed commercial technology. It also prevents many Coast Guard and other government field personnel from operating as effectively as industry partners who have access to these tools.

Thank you again for the opportunity to share our story today. We believe that "blue economy" companies like PortVision are key enablers of enhanced maritime domain awareness and increased safety, security and efficiency across the marine transportation system. I look forward to your feedback and would be happy to answer any questions you may have.

Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability

David M. Slayton

Research Fellow, Hoover Institution, Stanford University

Co-Chair and Executive Director, Arctic Security Initiative

Written Statement for the Record to the United States House of Representatives Transport, Transportation and Infrastructure Committee, Coast Guard and Maritime Transportation Sub-Committee

21 May 2014

Chairman Hunter, Ranking Member Garamendi, and Members of the Committee, thank you for the opportunity to appear before you today. I am grateful for your kind introduction and welcome.

It is indeed an Honor and Privilege to be here today to talk about the creation of new and emerging ocean technologies, how such technologies could improve our government performance, the expansion of maritime commerce and entrepreneurship, and broaden our understanding of the ocean environment in support of vital US interests in the Arctic Maritime domain. Additionally, I am glad to discuss what we at Hoover and the Arctic Security Initiative view as impediments that limit or constrain the use of such technologies.

My interest in the oceans and the Arctic spans my entire personal and professional life, starting with my first trip to Norway at the age of 13 and then joining the Navy at 17. I grew up living and working on the ocean and then in my professional life, operated in the maritime environment, worldwide to include the Arctic - for almost 28 years.

When we spend our time at sea, thinking about the oceans and the implications of climate change and security around the world, particularly from the standpoint of our maritime interests, one is compelled to think deeply about marine technology, the maritime envirionment and the Arctic.

While I was on active duty as a senior officer in the U.S. Navy – there existed two areas beyond Naval Aviation that were of significant interest. The first was energy. What were the future energy outlooks globally and nationally from the standpoint of being able to look and see where there might be conflict, strife and friction – geo-political implications?

Then the second area was climate change. And this had a couple of components to it. One, as we look around the world, and we see the changes that are taking place, those changes have effects. Effects on water supplies for many populations around the world, agricultural forecasts, and if you overlaid demographics on where the climate is likely to change significantly, then we get a good sense of where there can be friction, where there can be needs for humanitarian assistance,

disaster relief, where we will see the convergence of climate change and serious security implications, so we were looking at it from that standpoint.

Then, a large component of climate change is what is happening in the maritime domain and the Arctic. We at the Hoover Institution tend not to get into what we call the "theological discussions" of climate change. But we do look at what "is" happening to the planet. What does climate change mean for our Security, our Economy and our Environment?

And I am pleased now to be at the Hoover Institution and Stanford, where I can continue working on Energy, Climate Change and the Arctic with the great support of the Shultz-Stephenson Energy Taskforce. Moreover, I would like to say that with the extraordinary support of Secretary George Shultz, who personally is involved in this effort, has an interest in the Arctic, and brings an incredible amount of perspective, insight and leadership to the work that we are doing at Stanford. We are also fortunate to have our work informed by former Secretary of State Condoleezza Rice, our recently returned Ambassador to Russia, Michael McFaul and a number of other scholars, practitioners and professionals from Stanford, Hoover and indeed, from around the world.

What I would like to do is start with a few thoughts and some observations, related to why we are all here and the project that we are working on at Stanford; the Arctic Security Initiative. All of us here know we are experiencing the most significant physical event on our planet since the end of the ice age, it is taking place today – the opening of the Arctic. Activity in the high north will continue to increase. Fish stocks and pursuing fishing fleets will migrate and move farther north. Access to staggering amounts of resources will expand. New maritime shipping routes have the potential to reduce shipping times, cut costs and accelerate ties among commercial centers. Indigenous populations will be affected profoundly and rapidly

As recent events in Russia coupled with ongoing climate change have highlighted, the Arctic has reemerged as a significant policy issue, in part due to the region's abundant energy, mineral and natural resources. As climate change makes the Arctic more accessible, new potential maritime routes promise to reduce shipping times, costs, and accelerate ties between major commercial centers. However, the increased activity suggests that the region is likely to become the subject of intensive negotiations, possible friction and confrontation. We in the United States need to be prepared, presently – we are not.

While the issues are many and not without challenge on many levels, the interaction and cooperative tone among the Arctic states afford opportunities to open the Arctic in a safe, secure, prosperous and responsible manner. Now is the time to approach our Arctic interests and responsibilities urgently and as a national strategic priority. The Arctic Security Initiative at the Hoover Institution is addressing that strategic priority by bringing together experts in maritime law, energy, oceanography, technology, communications and shipping.

Towards these efforts, Hoover's Arctic Security Initiative will increase awareness of Arctic issues and propose policy measure recomendations that will enable industry to develope "game changing" maritime technologies, pressurize that technology thru gaming, simulation and rigorous debate to demonstrate how such technologies can change federal and international regulatory and safety regimes; make recommendations on how federal agencies review and adopt such technologies; and evaluate the impacts such technologies can have on improving efficiency and safety of the maritime industry; and how the federal government adopts such technologies to support vital US interests.

We recognize the increasing accessibility of the Arctic Ocean is leading to greater commercial activity in that part of the world. In addition, non-Arctic states are beginning to take interest in the potential advantages the Arctic may afford them. The United States finds itself in a position where it does not have the proper government assets to operate beyond a very minimal capacity in that part of the world. In order to make informed investment decisions, a comprehensive

survey of the decision environment is required. To date, no such review appears to have been accomplished.

Our team at the Arctic Security Initiative works to inform the country and the US government that the United States "IS" one of eight Arctic nations, that we will face directly the changes, challenges, opportunities and responsibilities of the Arctic evolving as a strategic territory. While access will increase, the region will remain a challenging place. The past few years have seen the least amount of ice coverage in recorded history but the stormiest one on record. This coupled with the fact only a small percentage of the Arctic has been surveyed to enable safe navigation; and navigation and communications systems, commonplace in other regions of the world, are absent or degraded in the high north. The physical infrastructure to support resource extraction, commerce, environmental response and inevitable search and rescue operations is scarce. Our Coast Guard and Navy, stretched thin by other global obligations and significant budget constraints, must now add the high north to their areas of operations.

Legal schemes for the new maritime transit routes are evolving and the basis for addressing resource claims and disagreements will be the UN Convention on the Law of the Sea, an agreement to which the United States regrettably is not party. Next year, the United States will follow Canada as the Chair of the Arctic Council, the forum that addresses issues faced by the Arctic governments and indigenous people.

Additionally, when we speak on the Arctic we remind audiences that the Arctic and the Antarctic are very different. The simple and narrative way that I like to describe them is that the Antarctic is land surrounded by water, and the Arctic is water surrounded by land. Moreover, for those of us tied to the sea, the oceans, the maritime domain - when there is more water -- we tend to get excited about that. And, we need to pay close attention to it.
To build on this overview, allow me to frame the discussion further within four domain areas we at Hoover consider quite foundational, seminal.

First, we look at the Arctic from the standpoint the tremendous resources in the high North, and we expect that people, organizations and nations will seek to develop those resources.

Next, is the environment, what is happening to this pristine geographic area on the earth, an area that really has not been greatly affected by humans over time.

Further, another deeply important aspect is the indigenous population and peoples that exists in the Arctic.

Finally, is security. And by security, our view and what we're working on at Hoover and what we talk to our government about is NOT the military dimension exclusively, but what must be in place in the high North, and the area that's opening up in an unprecedented way – what needs to be in place to ensure a safe, secure, and prosperous Arctic?

When people talk about the resources in the Arctic, it is very easy to visualize drilling rigs, and all of the activity that goes with it to extract energy from the earth, whether it is oil or gas. Nevertheless, there is a lot more in the way of resources in the Arctic. The largest zinc mine in the world is in Alaska, the Red Dog Mine. In Siberia, there are large nickel and copper mines. In Canada, a huge iron-ore mine on Baffin Island. And in southwest Greenland, there's estimated to be one billion tons of iron ore. And this is not just speculation, because the Chinese have seen fit to invest $2.3 billion in southwest Greenland to go after that ore.

So when we talk about resources, those are significant, remembering that doesn't account for the resources that are on the sea beds. That too will be of value to individuals, organizations and world populations. And then when we look at the estimates on the undiscovered energy resources, 30% of the undiscovered gas is estimated to be in the Arctic, and 13% of the world's undiscovered oil is in the Arctic.

That leads us to the environmental issues once you move away from the resources, because people will be coming for the resources. They already are. What are some of the environmental issues that come into play? As we know - it is still a very, very harsh place. As mentioned, we

recently experienced the stormiest year in recorded history. That, coupled with the fact it is dark most of the time. The capacity and capability to move and respond to events in the Arctic, the infrastructure quite frankly is not there, and our Coast Guard has led some exercises there to test and to try to determine how the United States will respond to events that take place in the high North. Another impacted area, the shoreline. Because of the climate change taking place, the shoreline in Alaska is changing dramatically. The ice is breaking off from the shore. In some cases, the ice is crushing into the shore as it moves around. The permafrost is melting and heaving up the earth, so the structures that are already there, are being damaged and in some cases destroyed. In addition, as that permafrost is melting, there are large quantities of methane gas being released into the air. There will be, as the warming trend continues, a movement north of vegetation, migration of wildlife and insects and what will that do with regard to disease factors that may be carried by those insects?

So there are many environmental considerations that are going to come into play, how do we respond? What's the best way to respond to them?

When we look at indigenous populations in the Arctic, their way of life may be ending, a way of life that for millennia they have lived as subsistence culture of hunting, sealing, fishing, and whaling. Their communities will no longer be in positions to be able to do those activities as before. An estimated four million people live in the Arctic, and that four million is beginning to migrate a bit. In addition to this migration, the resource extraction industries that are being further developed in the Arctic, are bringing non-Arctic populations to the high North. Large numbers of people from Central Asia, Poland, there is even a large Thai community up in the high North areas working on the energy and resource development sites.
And it's that population that also distinguishes the Arctic from the Antarctic. Four million people live above the Arctic Circle. No indigenous peoples live or have ever lived in the Antarctic. A lot of penguins, but no people.

When we look at the security requirements, the US and other Arctic Nations need the capacity and capability to support, respond and react to the events that are taking place. Moreover, when we look at security – as we have said, it is about safety, adequate and able response for

environmental or other accidents that might take place in the high North, and it is there that our Coast Guard is going to be on the front lines of anything that happens in the Arctic.

So what we're doing is looking at what's the most thoughtful, what's the best and most responsible way to move forward, because the Arctic is changing quickly, and the United States is an Arctic nation. If you go to the state of Alaska, you come away knowing the United States is an Arctic nation. If you go to other places in the US, I am not sure that you come away with that same sense. Nonetheless, we are at a period of time, with these changes are taking place, that the United States needs to start making some strategic decisions, we have to start making some significant investments.

We need to decide and then "act" on how we want to posture ourselves in the Arctic, and we are having to do it at a time when we do not have a lot in the way of budgetary flexibility.

Last February, the Navy released the U.S. Navy Arctic Roadmap for 2014 to 2030, a document outlining a naval planning framework for the region. The document lays out various necessities for Naval capabilities in the Arctic, from new satellite communications equipment to cold-weather training exercises. The Navy's road map followed the Department of Defense's "Arctic Strategy" report of November 2013 and the White House's May 2013 "National Security Strategy for the Arctic Region." The documents together make up a nascent Arctic strategy.

Recognizing that more needed to be done, in January of this year, President Obama released the US Implementation Plan for the National Strategy for the Arctic Region in an effort to better direct and coordinate all of the aforementioned strategies.

The President's plan aims to provide guidance to a host of federal departments and agencies. In part, the plan can be viewed as the initiation of an "integrated Arctic management" process with a clear objective to engage with the state of Alaska, Alaska natives, and key stakeholders and actors from industry, academia, and nongovernmental organizations.

For the maritime domain, the plan presents a ten-year horizon that will be used to prioritize federal infrastructure in the U.S. maritime Arctic. The plan also calls for a ten-year projection of Arctic maritime activity to be completed by the end of 2014. This will be a very challenging task given the great number of economic, environmental, and geopolitical uncertainties influencing Arctic marine operations. Determining accurate ranges of quantitative information on the levels of Arctic traffic has proved to be elusive given the volatility of global commodities markets and the dynamic nature of the global shipping enterprise, among other key factors. It is not surprising that within the section on the maritime domain the plan calls for recommendations for federal public-private partnerships to support the prioritized marine infrastructure elements that are to be developed by the federal agencies.

This may prove to be an early indication that, without investment partnerships with the private sector, new initiatives such as U.S. Arctic economic development may be constrained or limited by the federal budget process.

The plan recognizes a number of key requirements that relate to a changing U.S. maritime Arctic and its future. Included are major initiatives on developing telecommunications services, enhancing domain awareness, sustaining federal capability to conduct maritime operations in ice-covered waters, protecting the Arctic environment and identifying sensitive areas in the U.S. maritime Arctic, increasing charting in the region and improving geospatial referencing, improving oil and other hazardous materials prevention, containment, and response, and supporting a circumpolar Arctic observing system. This is just a subset of the many tasks presented in the plan but it is clear that the maritime domain requires special and timely attention using integrated approaches that can respond to a broad array of security challenges.

Recently at the Chicago Council on Global Affairs, US Secretary of Defense Chuck Hagel stated: -

"We also must adjust our capabilities to meet new global realities, including environmental changes. Just today, the nation s top scientists released a National Climate Assessment that

warns in very stark terms that the effects of climate change are already becoming quite apparent. One area where we see this is in the Arctic. The melting of gigantic ice caps presents possibilities for the opening of new sea lanes and the exploration for natural resources, energy, and commerce, and also the dangerous potential for conflict in the Arctic. The Defense Department is bolstering its engagement in the Arctic and looking at what capabilities we need to operate there in the future - as described in DoD s first-ever Arctic Strategy that was introduced at the Halifax International Security Forum last November."

The US can ably and well develop strategies and discuss plans – as the saying goes, talk is cheap. Nevertheless, a strategy or a policy in my mind, without a budget, is nothing more than a wish, it's almost nothing. Therefore, our goal remains to inform and further motivate some of the thinking of the US Government to act, fund and fully resource a serious Arctic strategy and policy.

The areas that we are looking at in a disciplined manner at Hoover are, for example, the infrastructure piece. How do we put in place the airfields? The Ports, The bases?
The staging of equipment that may be required to respond to some of the challenges, to the recently formed Search and Rescue agreements and spill response? We only have one deep-water port in the Arctic, Dutch Harbor, Alaska and it's about as far from the Arctic as you can get in Alaska. But it's still considered to be an Arctic port, and it truly is.

Another issue that we face is that even though it appears at times most of the ice was flushed out of the Arctic Ocean, the fact of the matter remains that ice, like politics, is local. We expect to find for some time to come areas where the ice has closed harbors, or closed shipping routes. And so how do we clear that? And one of the challenges that we as a nation have and more specifically, the Coast Guard has, is our icebreaking fleet. And even though it may look as though the ice is all gone, icebreakers will be required to get in and out of places that are going to be important to us and others economically. Icebreakers will be required to respond to events, whether it is a search and rescue operation or an environmental problem. And let me just give you a sense of the Arctic nations' icebreaking capability. Russia has 43. Sweden has nine. Finland has nine. Canada has 13. And the United State has two. And one is around 40 years old,

a great ship...Forty years. And so how do we think our way through that, and what's the best way to reconstitute that Icebreaking capability that will be required? US Navy and Coast Guard Ships that operate in the oceans today aren't equipped, aren't hardened, don't have the systems on board that will allow them to operate in that harsh, cold, and at times rough Arctic climate, so those too are some of the investments that will have to be made.

Communications and navigation in the Arctic is very different as we know. When we get above about 74 degrees north latitude, the communications that are so much a part of how we move around the world today are not as robust, are not as reliable, do not have the capacity and bandwidth that we've become so used to in the world in which we live.

When we look at the bottom of the Arctic Ocean, only about 10% has been surveyed. So as we look at a nautical chart, where many surveys have been done in other parts of the world, only 10% has been done in the Arctic, and most of those surveys are between 50 and 80 years old. So we have a bit of a backlog to deal with and much work to do. But we're pleased as we look at these challenges of communication and navigation that we are embedded in Silicon Valley and Stanford University where we're getting some great support, also from the University of Alaska, University of California and Georgia Tech, where they've been thinking about this problem for quite some time. We look forward to further collaboration with the University of Tromso and the Norwegian Institute for Defense Studies and others as well.

The other area that will come into play in the Arctic is shipping. Globalization and climate change are affecting Arctic shipping in extraordinary ways. The Arctic is being increasingly linked to future global markets by the development of offshore and onshore natural resources. These developments require Arctic marine transportation systems that are safe and reliable, and, importantly, a host of marine infrastructure improvements are needed to ensure safety and efficiency.

Hydrocarbon exploration in offshore Arctic areas of Norway, Russia, Greenland, and the United States have required extensive summer marine operations using small fleets of support ships, including icebreakers. Russia's Northern Sea Route, a set of Arctic waterways across the north of

Eurasia from Kara Gate in the west to Bering Strait in the east, has experienced an increase in tanker and bulk-carrier traffic during recent, summer navigation seasons.
Most of the central Arctic Ocean is being explored in summer by icebreakers and research ships in support of the delimitation of the outer continental shelf by the five Arctic Ocean coastal states. Simultaneous to the notable increases in marine traffic driven by economic interests, Arctic sea ice has been undergoing profound changes in thickness, extent, and character in the current era.

As new sea routes open they will connect the world in different ways than we have seen before. Without question, there has been a significant change in the percentage of shipping, but I would also say that we have to be mindful that is due to the law of small numbers, those numbers will continue to increase.

Arctic tourism has taken off in recent years and the US Coast Guard's most recent Arctic strategy is forecasting over a million tourists in the Arctic in the next year. Large cruise ships and specialized expeditionary (tourist) vessels have been operating during summer in eastern Canada, along both west and east Greenland coasts, and around Svalbard in increasing numbers.

With this in mind, let's recall Costa Concordia, lying on its side off the coast of Italy, where most people could just jump off into the water and swim ashore. What's going to happen in the Arctic, where we don't have the infrastructure to go after them? And that's just one reason why the infrastructure piece is so important in my mind, to be able effect search and rescue on that scale, Humanitarian Assistance and Disaster Relief.

I think the challenges of extraction and natural resource development and the shipping that supports those efforts demand the same level of support and response. When Shell was working off the coast of Alaska, they had a number of ships up there that I think any Coast Guard or Navy would be envious to have in their service. Bottom line, these activities will require a significant amount of shipping and maritime support in the Arctic.

A little more on the Ice. During the past three decades, observations have shown that Arctic sea ice has continued to decrease in extent and thickness. Broad areas of the coastal Arctic Ocean have become ice-free during summer periods (September) when Arctic sea ice is at its minimum extent. However, the Arctic Ocean remains fully or partially ice-covered for much of the winter, spring, and autumn. It is an ice-covered ocean that requires international regulation (and standards), *not an ice-free environment*.

From the perspectives of marine safety and environmental protection, this is a critical, practical factor since future ships operating in Arctic waters will likely be required to have some level of polar or ice-class capability including suitable construction standards, ice navigator experience, and Arctic safety equipment. With this enhanced capability they can safely operate in extended seasons of navigation beyond the short summer operational period.

Global climate models (GCMs) simulate a continued reduction of Arctic sea ice extent. An entirely ice-free Arctic Ocean for a short period of time in summer is projected to occur before midcentury. Such an occurrence would mean that no more multi-year or "old" sea ice will remain in the Arctic Ocean and the region will have a seasonal, first-year ice cover in subsequent years. A plausible result is that future sea ice covers will be more navigable by ship, although this thinner ice cover will likely be more mobile under the influence of local winds.

Recent research has focused on how changes to Arctic marine access can be evaluated by using sea ice simulations from the Global Climate Models and a range of polar class ship types. Higher class ships, Polar Class 3 for example, have been found to gain significantly greater marine access, nearly year-round for much of the Arctic Ocean.
By midcentury, changing sea ice conditions may also allow lower polar class vessels, for example Polar Class 6 with a modest ice capability, and perhaps even non-ice strengthened, open water ships to cross the Arctic Ocean in September. None of these research results indicate that regular trade routes are possible, only that certain types of ships may or may not have marine access at specific times of the year, given a range of climatic projections.

However, this research does provide key information about plausible, and technically possible, seasons of navigation. The type of cargoes being carried and the economics of global shipping, along with governance and environmental factors, will determine which Arctic routes might be viable for seasonal, regular traffic.

For the U.S. maritime Arctic, this increase in marine accessibility plausibly means longer ice-free seasons for offshore hydrocarbon exploration in the decades ahead. Seasonal barge supply of coastal communities, and barge support to oil and gas projects, can expect longer summer seasons of relatively ice-free conditions for their operations along the northwest coast of Alaska. Sometime during the next two decades, an extended and reliable navigation season of six months could be attained by Russian authorities for the eastern reaches of the Northern Sea Route Specifically in the Laptev and East Siberian seas.

This expanded Arctic operation will likely result in commercial ship traffic sailing through western Bering Strait earlier in the spring and later each autumn. The ice-class bulk carriers and tankers will likely experience ice conditions along the Russian coast of Bering Strait during these early and late season voyages. This is in contrast to the normally ice-free environment during a long "summer" season throughout the strait. These are some of the challenges, and I was pleased to read recently where the International Maritime Organization has come out with an intention to have a polar code in place by 01 January 2017 for polar shipping.

But then, what are some of the indemnification rules that are going to come into play? And how do ships get insured? And what's the best way to deal with insurance as ships move through what is going to be a fairly challenging place?

I've touched on infrastructure – the infrastructure on shore – a couple of times. And I think we have to look at that hard ... because of the budgetary environment we're in, we're going to have to look at public-private partnerships that can support the range of activities that are taking place in the Arctic.

Then, how do we power the Arctic so that we are not creating emissions that will only exacerbate the changes that we are seeing already? And so we're going to be spending some time looking at what the energy requirements are going to be in order to support this increase in activity in the high North.

And then as we develop all of this and as others use the Arctic Ocean, who pays when there is a problem? Because it will be the Arctic countries that will respond to the problem, and that will come at a cost. So what will be the roles, goals and responsibilities of the other countries that are using the Arctic?

And that brings into play the governance of that space. Right now, we often talk about the Arctic as being the most cooperative place on the planet and arguably, apart from the weather, the most benign place on the planet.

The Arctic nations, the eight Arctic nations and the indigenous communities that are represented there, it really is a model of significant cooperation. We believe that it is very important, that governance model and that level of cooperation is maintained as we go into the future. We cannot allow ourselves or the world to be significantly distracted by the recent activity of Russia and its close neighbors – however, if left unmitigated – could result in a disruptive Arctic geo-political environment where there was once great cooperation.

Looking ahead, Canada has the chair of the Arctic Council, and in about a year's time - in May of 2015, the United States becomes the chair of the Arctic Council. Moreover, I think we have an opportunity, working closely with our friends and allies, of being able to develop a continuum of recent initiatives, work and progress that could be very, very helpful to maintain stability and an air of cooperation in Arctic matters.

On that theme, we are also looking at some of the maritime legal dimensions of the Arctic. As these new maritime transit routes come into play, and as the Maritime Arctic countries look at the routes that may come through some of their territorial seas, what are the requirements, and how does that affect our view toward what have become accepted international norms and

accepted elements of maritime law? And will there be initiatives to change that in ways that are helpful or perhaps not optimized?

Unlike in Antarctica, there is no overarching legal convention for the Arctic. The regime that now governs the region is a combination of legal arrangements including national domestic laws, bilateral agreements, global treaties (such as UNCLOS), customary law, and a variety of international maritime conventions negotiated under the auspices of the International Maritime Organization, including the International Convention for the Prevention of Pollution from Ships (MARPOL), The Safety of Life at Sea Convention (SOLAS), and The Standards of Training, Certification and Watchkeeping (STCW).

Shipowners, cargo owners, insurers, port authorities, and trade and labor union associations, among others, might also ordinarily play an indirect role as market participants in determining when and where shipping in the Arctic should occur and under what conditions. However, since the Arctic is not yet a venue for sustained shipping traffic very few commercial standards have evolved. The Arctic is still perceived as distant, remote and no concerted effort has been taken by the international business or legal communities to address the underdeveloped regulatory environment—even though the physical environment is changing rapidly!

But those are some of the governance issues that we have been taking a very hard look at.

And then of course, there's the issue of claims in the Arctic. We have talked about the resources that are in the high North and the exclusive economic zones. Then there is the subject of the extended continental shelf, what extends beyond the exclusive economic zone. And the United States is extraordinarily fortunate to have projections of an extended continental shelf that are really quite generous and quite prosperous.

However, the problem is those claims are going to be adjudicated through the Convention on the Law of the Sea, of which the United States is not a party. And the amount of area and the wealth that we are discussing is absolutely extraordinary. The estimates on the US extended continental

shelf is almost twice the area of Alaska The big difference is, that we had to pay for Alaska. We don't have to pay for the extended continental shelf.

That being said, gaining exclusive sovereign rights over the full potential U.S. Arctic extended continental shelf will prove difficult, however, due to the close proximity among the United States, Russia, and Canada and the potential for overlapping claims to extended continental shelves, and I think that's going to be problematic.

The potential implications of this extended continental shelf regime are profound. The U.S. continental margin off the coast of Alaska alone may extend to a minimum of 600 miles from the Alaskan baseline. Alaska's extended continental shelf lies over the Arctic Alaska province, one of the many oil- and gas-rich basins in the Arctic. It is estimated that there may be almost 73 billion barrels of oil and oil-equivalent natural gas located in the Arctic Alaska province, the second highest estimated production capability of all Arctic provinces. The continental shelf within the 200-mile EEZ under the Beaufort and Chukchi Seas alone may have over 23 billion barrels of oil and 104 trillion cubic feet of natural gas.

And then the other question relative to the United States accession to the Convention on the Law of the Sea is we will become the first chair of the Arctic Council that is not party to that treaty, what are the implications of that?

So we ask, what are some of the regulations and policies that we have in place, and what is still required, that will allow a responsible, practical means of addressing the Arctic issues? And I'm not sure the United States is well positioned, because if we look at what has happened recently, some of the companies that have been interested in doing some work in the off shore Alaska area have decided that they will move elsewhere because of the legal ambiguity, and what are the implications of that ambiguity? These are the questions we are attempting to answer.

To place a finer point on the themes highlighted earlier, the United States finds itself challenged now, early in the twenty-first century - to respond to a host of changes and uncertainties in its maritime Arctic.

Economic opportunities to develop the region abound as visibly evidenced by federal leases of offshore areas for hydrocarbon exploration. Future opportunities exist that require development of the maritime infrastructure necessary to facilitate shipping Alaska's Arctic natural resources, both onshore and offshore, to global markets.

From an environmental security perspective, the United States is especially challenged to provide a robust safety net to protect Alaska's coastal communities its world class Bering Sea fishery, and the Arctic marine environment in an era of expanding Arctic marine use.
The range of necessary policy responses and long-term investments
confronting the U.S. maritime Arctic is significant, perhaps daunting. Above all it is critical for the United States to ratify UNCLOS at the earliest opportunity.

With regard to Arctic shipping, the United States should continue to be proactive at the IMO in support of a mandatory polar code that must include all commercial ships operating in polar waters. The United States also should propose future IMO measures that focus on specific Arctic regulations, as well as developing port state control agreements with the Arctic states to enhance polar code enforcement. Timely application of a new IMO Polar Code to the U.S. maritime Arctic will require expedited regulatory implementation by the Coast Guard.
The United States, as one of the lead countries (along with Finland and Canada), should use the Arctic Council's Arctic Marine Shipping Assessment (AMSA) as a strategic guide and policy framework to protect the region's Arctic communities and the marine environment, and to enhance regional marine safety. Increased funding of NOAA for Arctic hydrographic surveying and charting is paramount if a safe maritime operating environment is to be secured, and coastal economic development can be initiated.

A comprehensive environmental observing system, a deep-draft port, and improved Search and Rescue and environmental response capacity and capability are among the critical infrastructure needs for the future of Arctic Alaska. Public – private partnerships must be conceived and fostered to ensure that adequate funding is available for large, maritime infrastructure projects such as a major port during a time of austere federal budgets.

Nevertheless, strategic investments in Arctic infrastructure by the federal government will be required to enhance public safety and security, and advance economic opportunity in new partnerships.

The U.S. federal government must better execute its legal responsibilities and implement its promise of using an integrated Arctic management approach in the region. These challenges will necessarily require close federal-state of Alaska cooperation and greater stakeholder engagement. The future of Alaska and the future of the United States as an Arctic nation depend on sound strategic planning at the outset of new national initiatives. Thus, the timely Implementation Plan of the National Strategy for the Arctic Region (2014) as a framework for federal process is essential. Executed in a comprehensive and integrated manner, these actions can enhance America's National Security, Economic strength and Environmental interests in its large maritime Arctic.

In closing, while the issues are many and not without challenge on many levels, the maritime industry and entrepreneurial maritime clusters of this nation afford great opportunities. Now is the time to approach our maritime and Arctic interests and responsibilities urgently and as a national strategic priority.

Thank you again, Mr. Chairman, Congressman Garamendi, and Members of the Committee, for the privilege of appearing before you today. I look forward to the remainder of the hearing and would be pleased to respond to your questions.

David M. Slayton
Executive Director & Co-Chair, Arctic Security Initiative
Research Fellow
Hoover Institution, Stanford University, CA 94305
www.hoover.org/fellows/commander-david-slayton
dslayton@stanford.edu

HOOVER INSTITUTION
STANFORD UNIVERSITY

27 JUNE 2014

MEMORANDUM FOR THE RECORD

From: David M. Slayton, Research Fellow, Hoover Institution, Stanford University, CA 94035
To: The Honorable John Garamendi, Ranking Member - Subcommittee on Coast Guard and Maritime Transportation

Subj: Questions for the Record from Congressman John Garamendi, Hearing on "Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability" May 21, 2014

Encl: (1) 'Earth Systems Prediction Capability' or ESPC Overview

1. Please find my best effort and informed responses to "Questions For the Record" in the order they were provided on 02 June 2014.

National Research Council 2011 Ocean Infrastructure Recommendations

In 2011, the Ocean Studies Board of the National Research Council released a report entitled, Critical Infrastructure for Ocean Research and Societal Needs in 2030. This forward-thinking report recognized that a coordinated national plan for making strategic investments in ocean infrastructure was necessary to maintain fundamental ocean science research over the next twenty years.

Furthermore, the report stated that a growing suite of infrastructure will be needed to address urgent societal issues, including tsunami detection, climate change, and offshore energy development and fisheries management. The report also offered several recommendations, notably the need to support continued innovation in ocean infrastructure development, and to engage allied disciplines and diverse fields to leverage technological developments outside oceanography.

- ***Question:*** *To your knowledge, have Federal agencies embraced the recommendations made by the Ocean Studies Board? Has the effort been made to develop a coordinated national ocean infrastructure plan to help guide the private sector and ocean research community on where they should best focus their energies?*

  Answer: *No. The Federal Government's lack of substantive investment with regard to the Ocean Studies Board's goals, direction and recommendations are obvious. The U.S. Government needs to prioritize and accelerate the establishment, support and maintenance of a coordinated interagency strategic plan of action and investment for shared ocean infrastructure. Actions and investments in the 3 years since the release of "Critical Infrastructure for Ocean Research and Societal Needs in 2030" have been wanting. In light of the current administration's emphasis on climate change, real and growing security and economic challenges linked to the changing climate and greater impact on our vital U.S. interests, this lack of action and investment places our nation, advanced ocean research and ocean focused scientific community at risk.*

  It is imperative to build the comprehensive range of ocean infrastructure recommended, it will be needed in the coming years, and I would argue, based on the time lines required to build this infrastructure and capacity – we are now "late to need". The U.S. needs to implement an actionable plan that leverages trends in science and advances in "Game Changing" technology, while acknowledging factors such as costs, efficient use, and the capacity to cope with ever increasing and dynamic climate driven events.

  Finally, Federal agencies can leverage and maximize the value of ocean infrastructure by following a number of best practices, to include but not limited to- efficiently managing resources, providing more access to data and facilities, fostering collaboration at many academic, government and industry levels, and enabling the transition from research to broader ocean based industries, application and use.

- ***Question:*** *Does this plan generally align well with the most important scientific questions and priorities of the ocean science and research communities?*

  Answer: *Somewhat, yes. The plan's four priorities are; enabling stewardship of the environment; protecting life and property; promoting economic vitality; and increasing fundamental scientific understanding provides a sound framework. Of these, the "top two", in my opinion are- 1) promoting economic vitality; and 2) increasing fundamental scientific understanding. Enabling stewardship of the environment and protecting life and property will result from effectively funding and implementing the "top two" – Bottom line, ocean monitoring and surveillance are critical enablers for increased national security, a better economy and an improved environment. As a nation, we need to turn the ideas of the Oceans Studies Board into action.*

- ***Question:*** *In general, does this type of plan, one that identifies priorities and investment strategies for Federal agencies, help or hinder private sector firms? Can it function as a constraint on science and technology innovation?*

  Answer: *Credible and reliable government action, investment and commitment would greatly facilitate private sector firms. This would aid in developing distinct and recognizable demand signals to industry. Additionally, the associated regulatory and legal ambiguity associated with operating at sea needs to be reduced and mitigated.*

National Integrated Ocean Observation System

In 2009, building on the initiative of the ocean science community, the Congress passed legislation providing an organic authority for the establishment, administration and operation of a National Integrated Ocean Observation System, or IOOS. Since then, IOOS has continued to mature and expand its monitoring, observation and data sharing capabilities. Most important, IOOS has more than demonstrated its versatility and value providing information vital to Federal responses to recent disasters, including Hurricane Sandy and the DEEPWATER HORIZON oil spill, and to improving the accuracy and efficiency of Coast Guard Search and Rescue operations. Most witnesses at the hearing spoke positively about the multiple benefits now available through investments made in IOOS infrastructure.

- ***Question:*** *In your opinion, how can we best support IOOS to ensure the continued build out and expansion of the planned IOOS architecture, and the further integration of IOOS data into basic and applied ocean science research?*

  Answer: *In a capability sense, IOOS is riding the wave of technical innovation in ocean instrumentation created largely by ONR (in situ instruments and platforms) and NASA (satellites). As funding at ONR shifts to more militarily relevant capabilities (e.g. rail guns vice oceanography) a key national investment in ocean science capabilities fades away. For example, one key need is to ensure engagement of a technology-development savvy organization in the development and maturation of ocean technology. Such organizations are very rare – ONR excelled at this for ocean technology, particularly during the cold war and immediate post cold war period. Renewing and re-energizing ONR engagement would be extremely beneficial to existing and ongoing IOOS efforts.*

  There is also the reality that limited funding has forced hard choices. The IOOS teams have attempted to become more operational, and as a result, critical research sites have been allowed to degrade. Coincidentally, shortly after the hearing, we received word that the IOOS HF radar (which measures surface current) in the Monterey Bay area is down again, making a particular ONR funded research activity impossible. The system is often down, as Monterey Bay is no longer a priority for high resolution HF radar coverage, despite the area's key role in technology development (e.g. Monterey Bay was where much of the HF radar technology was developed). Monterey Bay is clearly not as critical as SF Bay, from an operational perspective, given San Francisco's economically

important port. On the other hand, Monterey Bay is a hot-bed of ocean science research, and by allowing Monterey Bay assets to fade away, IOOS effectively disengages itself from the new generation of ocean science researchers.

- ***Question:*** *How can we best ensure that the private sector is able to continue to develop innovative products and services derived from observation data gathered by IOOS infrastructure?*

  Answer: *The last paragraph above applies to the private sector as well. Reliable observational assets in key locations are central, of course. However, it is also important to recognize that much more capable - and potentially cost effective - systems can be created if experimentation is enabled. Thus the needs of private industry coincide with researchers in that some very well instrumented sites where experimentation can be encouraged and supported are essential.*

- ***Question:*** *Have the eleven certified IOOS regional associations performed as expected? If not, what recommendations might you provide to enhance the capabilities of the regional associations?*

  Answer: *Yes, they have ably performed through a combination of sheer grit, determination and smart risk taking, that being said- they could be doing much more if properly resourced and supported. The well of good will and great science is running dry. They have accomplished a great deal with comparatively minimal resources – those involved need to be recognized for their efforts.*

- ***Question:*** *To your knowledge, has any analysis been completed to determine the level of economic activity leveraged by Federal and non-Federal investments in IOOS infrastructure? Should authorized funding levels for IOOS be increased?*

  Answer: *The economic linkage studies are - to the best of my knowledge - quite old, and probably significantly underestimate the economic value generated by IOOS. Many capabilities in routine operation today (e.g. certain types of undersea vehicles) were not even conceptualized when the IOOS vision was created. Further, technical innovations like mobile computing, app markets, and supporting cloud infrastructure allow a much broader dissemination of IOOS products in a much more user friendly form.*

  To build on the previous answer, IOOS is greatly underfunded, and funding should be significantly expanded. Although IOOS is an NOAA entity, other agencies such as ONR, NASA, and NSF are key to IOOS success. Consequently a funding portfolio should be developed that supports each of these agencies, in addition to NOAA, for their specific contributions.

Need to Maintain STEM Funding

As I mentioned in my opening remarks at the hearing, the United States remains the world's leader in science but its preeminence is now being challenged aggressively by international competitors, notably China and India. Some people believe that this circumstance is directly related to insufficient funds being invested to support STEM education in the United States.

- ***Question:*** *From the standpoint of marine engineering and technology development, how important is it for the United States to maintain its investments in STEM education?*

  Answer: *Extremely important! Technology is changing rapidly and many of these new technologies and developments find their way aboard ships including such things as controlling adverse effects from ballast wastewater, improving fuel efficiency, decreasing air and water pollution, introducing bio-fuels, incorporating global positioning methods, etc. Students majoring in marine engineering technology and mechanical engineering at Cal Maritime need to have a fundamental knowledge of mathematics and science when they arrive on campus and, therefore, STEM education in K-12 is vital.*

- ***Question:*** *Is it practical to believe that the United States will be able to maintain its competitive edge against other global competitors if we fail to invest sufficiently in STEM education?*

  Answer: *Quite simply, the United States will not be able to maintain its competitive edge against global competitors if we do not invest sufficiently in STEM education. In 2009, the United States Department of Labor listed the ten most wanted employees and eight of these require intensive knowledge in science and mathematics. If we do not invest in STEM education in K-12, when students arrive on college campuses, they will be ill-prepared to survive the demands that STEM related fields require even if they may have the desire to pursue a STEM related degree. As a country we will be unable to fill much needed positions in areas such as computer science, electrical engineering, mechanical engineering, computer engineering, civil engineering, economics and finance. Hence, we will eventually lose our competitive edge.*

- ***Question:*** *Regarding maritime education, how important is it for the Congress to continue to provide financial support for the U.S. Merchant Marine Academy and the six state maritime academies?*

  Answer: *It is vitally important for the Congress to continue to provide financial support to the U.S. Merchant Marine Academy and the six state maritime academies. The program requirements to obtain a baccalaureate degree and license in the maritime fields are much greater than a typical baccalaureate degree. For example, a degree in history requires a minimum of 120 credit hours whereas a degree in a licensed mechanical engineering program will require as many as 150 credit hours. Furthermore, a degree in the maritime fields also requires numerous laboratory courses*

using very expensive laboratory equipment. As a result of the above two factors, the cost per degree for the maritime fields is much greater than a typical non-maritime related baccalaureate degree. The funding provided by Congress is necessary to offset the high cost associated with producing graduates in the maritime related fields.

- ***Question:*** *Is the type of maritime training made available through these institutions a necessity for future ocean science and research?*

- ***Answer:*** *Absolutely! There are many technological problems and questions associated with the maritime industry that need to be addressed such as deceasing air and water pollution, controlling adverse effects from ballast wastewater, and improving fuel efficiency. The maritime academies provide an excellent launch pad for future ocean science and research and the problematic areas mentioned can be addressed through the training offered by the maritime academies. In addition, the maritime academies themselves will need to step-up to conducting more scientific and engineering research in maritime-related areas.*

Recommendations for Better Coordination between Public/Private Sectors

In general, ocean science research and engineering has been predominantly a collaborative enterprise between a select few Federal agencies, notably the U.S. Navy, the National Science Foundation, and the National Oceanic and Atmospheric Administration, with universities and private sector contractors. And while this model has produced substantial scientific achievements, I get the sense that more could be done to improve coordination, to better leverage Federal investments, to address emerging ocean science objectives, and to provide new markets for ocean technologies.

- ***Question:*** *What recommendations can you offer to improve the coordination of Federal agencies, both among themselves and with their extramural partners in the private sector and university community?*

  Answer: *By and large, agencies and individuals respond to incentives. Informal coordination happens from time to time between Federal agencies, particularly at the Program Manager level. Better coordination could happen though if the incentives were to view inter-agency collaboration where resources are involved as 'most important' and something to be preserved, even at the expense of internal pain, vice relatively low-priority trade-space. The Federal government has yet to design an efficient and effective process to make this work. Expecting OMB to be the 'protector' of all inter-departmental budget agreements is not realistic, and likely would deter substantive cooperation as PM's would see excessive OMB oversight as a detriment to their program. Similarly, the means by which substantive cooperation can occur across congressional authorization and appropriation committees is not clear.*

An example of an attempt at meaningful inter-agency collaboration is the funded 'Earth Systems Prediction Capability' or ESPC (high-level briefing card attached as enclosure 1). Funded in the DoD/DoN budget since FY13, this program is an attempt to fundamentally recapitalize the aging operational numerical weather, ocean and ice model structure of the United States. Led by the US Navy, the USAF, NOAA, NASA and DoE have all signed on. However, it is providing very challenging to coordinate these respective agencies' programs in a way that simultaneously uses the best capabilities of each agency while minimizing duplication and returning best value per taxpayer-dollar. While the program has high-level agency and OSTP support, the details frequently get bogged down in individual agency desire for control of maximum resources. 'Unique requirements' are frequently touted as a reason why each agency should go and develop its own program.

- ***Question:*** *What can be done to improve the Coast Guard's interaction and collaboration with the ocean research and Blue Tech communities to address the Coast Guard's operational mission needs?*

  Answer:
  The way forward is not clear. I strongly recommend GAO and OMB look for 'best of breed' and 'best practices' where an appropriate balance is struck between agency funding, control and participating in a greater national good and in support of vital U.S. interests. Think of ways to incentivize agencies down to the PM level to encourage this behavior, especially and particularly when budgets tighten. This is an area also ripe for pilot projects and the understanding that, without some failures, we will likely learn little additional information and probably not change behaviors substantively.

- ***Question:*** *Should the Coast Guard work more closely with the Office of Naval Research or Oceanographer of the Navy in areas of common interest, particularly in the littorals?*

  Answer: *With respect to USCG and ONR/Oceanographer of the Navy -- of course more coordination is a constructive and meaningful approach. But it would help if USCG can bring some resources to the table. Otherwise it is just more unfunded requirements (from another Cabinet Agency, funded by other committees) competing with a budget that already has seen serious and ongoing declines.*

UUV and UAV Security

Underwater Unmanned Vehicles (UUVs) and Underwater Autonomous Vehicles (UAVs) are assuming a greater role as a tool for ocean research. Additionally, greater attention is now being devoted to investigating the potential use of UUVs and UAVs for other purposes, including for Maritime Domain Awareness. Some questions have come up concerning both the cybersecurity and physical security of these assets once deployed in the marine environment, especially whether these assets might be co-opted, confiscated or otherwise compromised by our enemies.

- ***Question:*** *What are your views on the security profile of UUVs and UAVs in the marine environment? What can be done to prevent hackers from accessing and controlling these vehicles?*

  Answer: *The field of Information Assurance and Anti-Tamper is developing very rapidly. The experiences gained using Unmanned Air Vehicles (UAVs) in combat operations during the Iraq and Afghanistan campaigns have emphasized the importance of these factors and caused the application of increasingly robust features to protect the vehicles themselves and the data and information contained in their memories. It would be very difficult for protected data to be accessed by an unauthorized person, even if the vehicle were to be lost to an adversary.*

  UUVs are submerged and out of effective communications, much of the time- and in that sense have some security advantages. However, persistent platforms typically surface for satellite communications and GPS updates, and during that phase the potential exists for platforms to be either physically recovered or otherwise compromised. I'm not sure what other folks do, but our commands to the vehicles are encoded. I think they would have to get on our server (or Iridium servers) to be able to break into our command link, and of course they would need very specialized knowledge in order to successfully configure mission commands. I suppose it is possible - if they knew where we were operating - to position a ship at a surface location and (if they are very fast) grab a vehicle or usurp the Iridium link.

  'Hacking' into the vehicles can be made very difficult with the inclusion into the basic vehicle architecture of more sophisticated command and control protocols and additional communications encryption. While no system can be made completely immune to determined and sophisticated hackers, basic safeguards built into the architecture of the vehicle makes them very secure.

  What could be done to improve this? Oceanographic applications of underwater vehicles operate under a very tight budget. So imposing requirements on security that are not funded would likely simply curtail operations. It might be possible to create secure communications servers that handle encryption of satellite communications, and offer that as a service for vehicle operators. If it were a government funded enterprise, then it could offer the service for free to government funded science applications.

- ***Question:*** *What type of risk does this create for ocean science researchers or other maritime operators whose dependence on these assets for data gathering, communication, surveillance and other activities is projected to grow dramatically in the future?*

  Answer: *Increased security and protection of information (and the physical vehicle) can result in extra complexity and loss of ease of reconfiguring the vehicle or its mission. Cryptography equipment must be protected and managed, and this can distract from an*

operator's primary mission. Secure command and control protocols can protect information, but also force operators into a narrow or inflexible way of operating the vehicles and managing data collection, analysis, and distribution. The balance between complete security and unlimited flexibility must be carefully thought through in order to maximize the utility and capabilities of the vehicles and their sensors.

The ocean sciences have a long history of dealing with vandalism of unattended ocean equipment at sea. For example, the NOAA PMEL laboratory has maintained mooring in international waters for many years, and has extensive experience with this problem. In my opinion, Chris Meinig at NOAA PMEL would be the best person to talk to on this topic. So in one sense this is not a new problem.

International law protecting uncrewed platforms at sea will eventually be needed. However, most vehicle operators that I know are more worried about new regulations imposing operational requirements that cannot be satisfied on small, comparatively low cost platforms, than they are about vandalism or communications security of vehicles. UUVs have been successful because there has been no ocean equivalent of the FAA (FAA restrictions have greatly inhibited the introduction of UAVs in the US, of course).

Absence of GPS Back-up System

Global Positioning Satellites (GPS) enable researchers and engineers to communicate with UUVs and UAVs and enable these assets to operate independently and in extremely remote environments. Since 1995, the space-based GPS navigation system has become indispensable to national and economic security. Concerns have been raised that there is no available backup capability for comparable timing and location information, and that this gap is a significant liability for national defense, transportation systems, and ocean science research.

- ***Question:*** *How disruptive would the loss of GPS communication be for the operations and activities of your organization?*

  Answer: *Reliance on GPS is pervasive in almost all military, government, major industrial and research operations. Many systems cannot meet their requirements in the absence of GPS, and other systems rely on GPS in unexpected ways that would render them inoperative should GPS be denied. GPS is a technology that has enabled the emergence of UAVs as a mainstay of military (and, in the near future, civil) air operations; its absence would have the practical effect of grounding most UAVs.*

- ***Question:*** *What communication and timing and location information options would be available to you in the absence of GPS?*

  Answer: *There are a suite of technologies that facilitate timing and location in the absence of GPS. Inertial navigation systems, long in use for aircraft, remain the only self-contained, jam/interference resistant source of position information. Inertial*

navigation systems are inherently prone to drift, but "navigation-grade" inertial systems support UAV operation, though not all associated functions (e.g. targeting) without GPS over moderate periods of time. The next generation of inertial navigation systems, expected to come to market in the next 3-4 years, will be sufficiently small and affordable to extend this capability to smaller UAVs, which are more heavily reliant on GPS as of now.

The inherent drift of inertial can be constrained by fusing inertial data with information from other sensors. Stellar-inertial navigation systems will be available at a size and price point that is reasonable for large UAVs (e.g. GlobalHawk) and that will constrain inertial drift so it remains near GPS accuracy for extended time periods. Data from on-board imaging systems can also be used to constrain inertial drift, especially when those images can be correlated to georegistered imagery databases. Image-aided navigation is a maturing technology that is expected to reach UAVs in the near term.

Timing, also enabled by GPS, is not critical to UAV flight but does enable multiple on-board systems (e.g. comms) to function. Recent years have seen small atomic clocks, with very low drift, to come to market at size and price points that enable UAVs to maintain an on-board time reference sufficiently accurate for most functions.

- ***Question:*** *Should the Federal Government develop some kind of land-based GPS back-up system?*

  Answer: *A land-based backup system would greatly alleviate concerns regarding the dependence on many domestic systems on GPS, particularly for timing and operation of critical infrastructure.*

2. Thank you again, Congressman Garamendi. In addition, please extend the same gratitude to Chairman Hunter and the other Members of the Committee. I greatly appreciated the privilege of appearing before the committee, answering your questions and being a resource for the committee's important work in the service to our Nation.

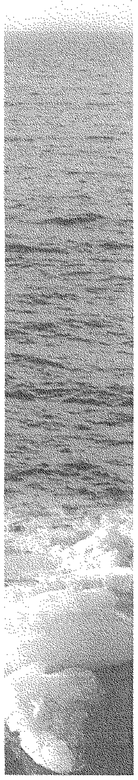
3. You may contact me by phone anytime: Office: [redacted] Mobile: [redacted] or e-mail: dslayton@stanford.edu

Very respectfully,
DMS
David M. Slayton

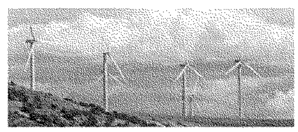
ESPC

EARTH SYSTEM PREDICTION CAPABILITY

The Earth System Prediction Capability (ESPC) is a developing collaboration between the National Oceanic and Atmospheric Administration (NOAA), U.S. Navy, U.S. Air Force, Dept. of Energy (DOE) and National Aeronautics and Space Administration (NASA). The Nation's security and economic well-being relies upon accurate global analysis and prediction capabilities for the physical environment over time scales of a few days to a few decades. This need for better informed decisions is amplified by recent trends in the climate mean and variability, which reduce the predictability of average conditions and extreme events affecting commerce, defense, infrastructure and water, energy and other resources. ESPC will improve environmental predictions and help decision makers address critical policy and planning issues by extending the National predictive capability from hours and days to seasonal, annual and decadal time periods through improved, coupled global environmental prediction.



VISION

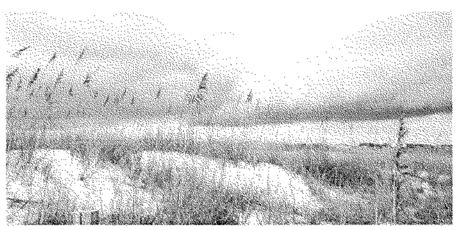


Establish a program to meet broad but specific agency requirements for an earth system analysis and prediction framework to support hours to decadal, global prediction at appropriate horizontal and vertical resolution including the atmosphere, ocean, land, cryosphere and space.

- Advance computational and environmental numerical prediction science and technology
- Enhance our understanding of complex interactions of the earth environment
- Extend predictive capability to decades
- Identify and quantify uncertainty and risk

NUOPC/ESPC

ESPC builds on the progress made by the existing National Unified Operational Prediction Capability (NUOPC) partnership. NUOPC is focused on implementing an operational, global, atmospheric ensemble system based on the current modeling technology at weather time scales and developing initial Tri-Agency collaboration and management including a common research agenda and common model architecture. ESPC is focused on the next generation system, an integrated earth system prediction, engaging multiple federal, private and academic organizations in a combined "revolutionary" research and development effort, including decadal scale climate prediction.

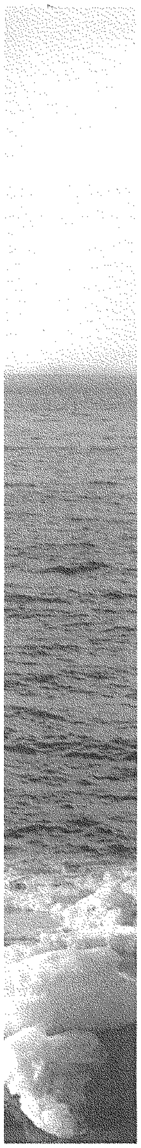


For more information:

Daniel Eleuterio, Navy
703.696.4303
Daniel.Eleuterio@navy.mil

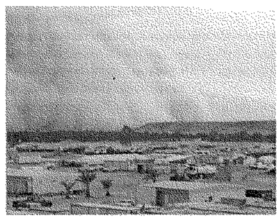
John Cortinas, NOAA
301.734.1198
John.Cortinas@noaa.gov

http://www.weather.gov/nuopc/espc



What is ESPC?

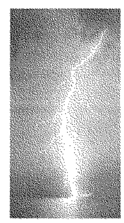
- A collaboration between NOAA, Navy, Air Force, DOE and NASA to develop a revolutionary earth system prediction capability and engage other federal agencies and academic partners involved in earth system modeling, research and development.
- A focus on extending prediction skill to decades to address the nation's societal and security issues that are impacted by the environment.
- An effort to make integrated ocean-ice-land-atmosphere and space predictions with a single system of systems.



Why ESPC?

Emerging predictive capabilities internationally in a changing climate require a National initiative for the best information to stakeholders. Complex environmental models to deliver these forecasts require resource focus and:

- World-class expertise from multiple agencies
- Coordinated set of agency requirements
- A system approach to extreme weather prediction, climate change impact and future energy efficiencies



Scientific Challenges

- Extending our predictive capability from minutes to decades through a better understanding of the earth system
- Modeling the complex interaction between the oceans/lakes, atmosphere, land, ice and ecosystems
- Using environmental observations to improve predictions
- Improving the representation of physical processes in earth system models
- Advancing our computational efficiencies and capability
- Identifying the uncertainty associated with environmental prediction

History

2005 Agreement by NOAA, Navy and Air Force Weather to explore a larger collaborative effort in prediction capability
Partnership and vision initiated with

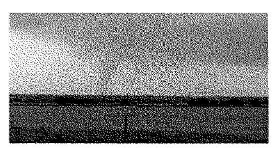
2006-09 Exploratory NUOPC workshops and initial ESPC discussion

2010-11 Development Team formed, initial Science/Technology workshops held and Interim Science Steering Group (ISSG) established

2012 ESPC Program Office and Inter-Agency Charter established

Recent Progress

- Plan to incorporate accomplishments and advances realized by NUOPC to enable transition to ESPC
- Partnership with Department of Energy to provide climate modeling and computational expertise/capacity
- Approval of ESPC, initial scientific challenges and proposals for major demonstration projects selected



WRITTEN TESTIMONY OF

Eric Terrill, Ph.D.
Director, Coastal Observing Research and Development Center
Scripps Institution of Oceanography
University of California, San Diego

BEFORE THE UNITED STATES HOUSE COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
SUBCOMMITTEE ON COAST GUARD AND MARITIME TRANSPORTATION

"Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability"
May 21, 2014
Washington, D.C.

Chairman Hunter, Ranking Member Garamendi, and members of the Subcommittee, thank you for the opportunity to appear before you today. My name is Eric Terrill, and I am the Director of the Coastal Observing Research and Development Center at UC San Diego's Scripps Institution of Oceanography (Scripps). At Scripps, I lead a team of technical staff in the operations and maintenance of distributed maritime and environmental sensor networks developed, deployed, and maintained by the Center. We partner with a number of federal and state agencies in our efforts to support national science and technical needs to sense and improve our understanding of the maritime environment.

A better part of my career has been dedicated to the field of ocean observing, environmental sensing, marine technology, and maritime domain awareness. I presently serve on a Federal Advisory Committee (FACA) for the U.S. Integrated Ocean Observing System (IOOS); a federal interagency effort led by the National Oceanic and Atmospheric Administration (NOAA). In 2003, I was part of the teams that founded, and remain the Technical Director of, the Southern California Coastal Ocean Observing System (SCCOOS) which is now a regional component of IOOS. I was also a lead scientist in the $21M California Coastal Ocean Currents Program, a pilot effort to map ocean currents using high frequency radar that now continues to operate after transitioning to NOAA. My team at Scripps has directly supported U.S. Marines during Operations Iraqi Freedom and Enduring Freedom with a network of real-time weather stations developed for unattended operation at forward operating bases. We also provide real-time wave observations to support training activities and the testing of new ships and surveillance systems for the Navy using expendable wave sensing technology developed at Scripps. I have served on teams responsible for transitioning new technologies to the Navy in projects sponsored by the Office of Naval Research and the Naval Surface Warfare Centers. I presently serve on a Maritime Domain Awareness (MDA) working group sponsored by U.S. Pacific Command (PACOM) to develop MDA solutions for small island nations in the western Pacific including the Republic of Palau and the Federated States of Micronesia. My education consists of a B.S. in Engineering and a Ph.D. in Applied Ocean Sciences – Physical Oceanography. Based upon my experience, I would like to communicate to the Committee that technical revolutions in micro-electronics, communications, and computational infrastructure are rapidly presenting opportunities for new ocean technologies to support growing U.S. MDA requirements.

Because Scripps Institution of Oceanography is involved in many, if not all, facets of ocean observation in support of MDA, I sought input for this testimony from various experts at my organization. I have also sought feedback on various topics from individuals within the USCG, US Navy, and NOAA. Aspects of my testimony on the specifics of technologies and data management are drawn from these sources and corroborated by my experience. My testimony is organized as follows: 1. Samples of historic and

ongoing ocean observation programs are provided as examples of the research community's role in supporting national MDA. 2. Suggestions for future MDA demonstrations, partnerships, and tools are outlined. 3. Examples of ocean technologies and the opportunities they present are provided; and 4. I provide closing recommendations for action.

1. Long-term Observation Programs Provide a Foundation for Environmental Knowledge of Maritime Domain Awareness

Founded in 1903, Scripps Institution of Oceanography became a part of the University of California in 1912. Scripps has a long history of supporting national defense objectives and has provided recommendations and technologies to "improve the efficiency, safety and security of maritime transportation" with a focus on the "better use and integration of maritime domain awareness data."

During World War II, Scripps oceanographers worked closely with the Navy to create surf and swell forecasts for successful Allied landings in North Africa, the Pacific, and the beaches of Normandy. Just as important, Scripps educated active duty weather officers so they could apply this new forecasting science on a daily basis to plan operations. Scripps researchers also developed high frequency underwater sound systems to track submarines and detect mines, enabling secure Naval operations and improving maritime domain awareness. Research at Scripps currently encompasses physical, chemical, biological, geological, and geophysical studies of the oceans and Earth, with annual expenditures approaching $200 million and a fleet of four research vessels and Floating Instrument Platform (FLIP). Scripps has a long history of initiating and maintaining environmental observing programs in the oceans, atmosphere and on land at regional to global scales. These observations are core to scientific discovery across numerous disciplines, and inform our understanding of society's most pressing issues.

In 1949, the California Cooperative Oceanic Fisheries Investigations (CalCOFI) was formed around a unique partnership between the California Department of Fish & Wildlife, NOAA Fisheries Service and Scripps Institution of Oceanography. The organization was charged with studying the ecological aspects of the sardine population collapse off California. 65 years later, CALCOFI still exists with a broadened focus to study and monitor the marine environment off the coast of California and its living marine resources. Its persistent sampling of the California Current Ecosystem provides insight into variations in ocean climate, and is now serving as a testbed for new technologies to monitor the ocean conditions which impact marine life. This includes ocean acidification, dissolved oxygen, and diversity of marine life.

In 1975, Scripps researchers launched the Coastal Data Information Program (CDIP), a program that measures, models, forecasts and publicly disseminates real-time coastal wave information, and that now includes a network of over 50 wave buoys in 13 states and island territories. CDIP provides these updated and accurate wave data to the US Army Corps of Engineers (USACE), the National Oceanic and Atmospheric Administration (NOAA), and other federal agencies. The conditions at the ocean surface impact all at-sea operations, and the data are critical for the operational maritime community to ensure safe and efficient navigation for military, commercial, and recreational maritime traffic, and are relied upon by dredging project managers for safe operations. CDIP buoys provide highly accurate wave height, period, and direction information, which are used as input to marine forecasts and incorporated into coastal inundation models. During Hurricane Sandy, the CDIP wave buoy network on the East Coast provided continuous, near real-time wave observations (reported every 30 minutes) without failure or interruption. In fact, over 99% of all data produced by CDIP buoys during the storm were successfully transmitted.

In 1998, Scripps led the development of the revolutionary array of ocean monitoring sensors known as the Argo network. Launched in 2000, the Argo program now deploys a global array of more than 3,600 free

drifting profiling floats to gather subsurface ocean data. Combined with satellite observations, these data make it possible to operate global and regional ocean analysis models similar to those for weather forecasting in the atmosphere. They provide enormous amounts of new information on the ocean's changing state at weekly to seasonal to year-to-year timescales. These observations and model analyses provide the data on open ocean conditions needed for tracking changes in ocean climate.

An existing framework that connects local stakeholders to regional observing systems and a federal backbone is the Integrated Ocean Observing System (IOOS). Initiated 14 years ago as an interagency planning office (Ocean.US) that has evolved to now having a formal program office within NOAA, IOOS consists of eleven Regional Associations connected through a federal data backbone that is supported by a set of data standards. IOOS has shared many successes including providing on-scene environmental information to many of the extreme events that the country has been faced with (Hurricanes Katrina and Sandy, Cosco Busan oil spill in San Francisco, Deep Water Horizon Oil Spill in Gulf of Mexico to name a few). As a decision support system, IOOS observations provides many of the 'behind-the-scenes' environment data that is leveraged for day to day decision making.

2. Improving the Use and Integration of Maritime Awareness Data: the Need for Technology Demonstrations, Technology Transitions, and Modular, Problem Driven Applications

Need for demonstrations and partnerships:
A significant investment of time, funds, and process documentation is required for a full scale analysis of developing technologies for USCG applications and implementation. Process studies through demonstration projects are one means to efficiently determine applicability and feasibility of new technologies. Scripps recommends developing partnerships with agencies within the Department of Defense that are already making investments in developing maritime surveillance systems. The Office of Naval Research (ONR) routinely conducts small scale demonstrations to develop and test new concepts of operations and technologies. These science and technology investments have the ability to provide a low cost, flexible, and timely analysis of capabilities that can transition to operational users. Science and technology in a spiral development allows the capability to incrementally evolve and improve with lower risk. Successful demonstrations can be scaled to support operations, while unsuccessful demonstrations provide valuable lessons learned and save significantly on a USCG-wide full scale information technology guidance procedure.

There is value in establishing and carrying out these demonstrations with the participation of other agencies. For example, there are USCG and Office of Naval Research partnerships that exist for research programs in the Arctic; and operational partnerships exist in the Joint-Interagency Task Forces (eg. JIATF-S, JIATF-W) for combatting illegal drug trade on the high seas. One year ago, the U.S. Coast Guard R&D Center requested assistance from the Office of Naval Research to host a classified workshop to share with USCG details on emerging naval systems that might be relevant to addressing the challenges of MDA including monitoring vessel traffic. The workshop included a broad range of subject matter experts and one outcome from the meeting was the identification of various concepts of operation for different MDA challenges facing the U.S. Defining demonstration efforts to tackle these challenges as follow-on to the workshop, and more importantly, resourcing the R&D Center to partner with other appropriate S&T organizations such as ONR should be considered a logical next step.

One example of ocean technology development driven by emerging mission requirements is ONR's investment in developing small unattended sensors to aid environmental sensing in the maritime environment. Near-real time meteorological and oceanographic (METOC) data is paramount for U.S. Marine Corp and Naval Special Warfare tactical scale operations, yet traditional means for rapidly sensing the environment at the right time and place is difficult due to high costs and the size and complexity of the technology. Forecasts at precise locations are perishable, and require constant update

of information for accuracy and verification. This places requirements on the need for tools to conduct timely synthesis of METOC information and to allow comparisons between models and data. For the last decade, ONR has made investments at Scripps and elsewhere to develop, test, and evaluate new sensors and operation procedures for improving tactical ocean and atmospheric environmental information collection. These efforts focused on developing techniques and procedures for best operational usage of powered unmanned underwater vehicles, low-cost weather stations, buoys, and wave sensing systems that communicate via satellite, and optimal methods for exploiting and fusing different types of data. These same systems could be used to track ocean conditions during hurricanes and provide valuable sea state information at offshore locations to support USCG operations and maritime commerce.

Another example of potential partnership and transition is the repurposing of land surveillance equipment. With the war in Afghanistan drawing down, opportunities are presenting themselves for applying investments in surveillance technologies developed and built for that theater to the maritime sector. For example, large and rapid procurement programs for aerostats and surveillance towers equipped with X-band radar and cameras were developed to provide force protection at forward operating bases. Large numbers of these systems were built to keep tempo with the escalation of Operation Enduring Freedom, and are now returning to the U.S. The same suite of sensors and networked architecture, with some modifications, may be well suited for providing capabilities to detect and track offshore vessels including illegal fishing boats. Maritime evaluations of these technologies are timely and currently being pursued on a pilot level by the U.S. Navy Naval Air Systems Command (NAVAIR) and Office of Naval Research. Scripps has supported these efforts both in the San Diego and overseas as part of fleet demonstrations in the Philippines. This summer two systems will be deployed in the Republic of Palau in partnership with U.S. Pacific Command (PACOM). Expanding the evaluation and demonstration of these technologies within U.S. waters in conjunction with U.S. law enforcement agencies and USCG is recommended, perhaps through a West Coast demonstration that would fuse various technologies and stakeholders. Supporting the U.S.'s expanding role of supporting MDA in the Pacific region, whether through expanded partnerships as part of our Pivot to the Pacific in Asia-Pacific or nations with Compacts of Free Association (Federated States of Micronesia, Palau), will be a future challenge for MDA technologies that can only be answered through systematic tests that will define appropriate strategies.

The Arctic presents another set of challenges for ocean technology developmentto support MDA. Arctic ice has begun to retreat, and is forecasted to continue doing so for the coming decades. As a result, maritime commerce, including the world's navies, is expected to begin taking advantage of new Arctic shipping lanes during summer months. Commercial activity on the sea floor is also expected to grow. Arctic waters are poorly observed, and the size and isolation of the region presents unique challenges to sense vessel traffic and ocean conditions. Characterizing the changing operational environment in terms of ice coverage and sea state will be required before new infrastructure, including floating offshore platforms, can be designed to operate in this extreme environment. Partnerships developed with the Navy, NOAA, National Science Foundation, and DARPA should be considered to leverage the respective investments of those agencies in improving U.S. sensing and forecasting capability for the Arctic.

Tools needed for interfacing to data:
The Government Accountability Office report on the USCG implementation of the Common Operational Picture (COP) identified a number of concerns with regards to data sharing and displays. The use of mapping overlays for data visualization can be extremely useful for displaying observations that assist in USCG missions such as search and rescue operations, marine safety and security, marine environmental protections, and ice operations. There is a wealth of direct observations and derived products that can be integrated into these systems including, but not limited to:

1.) Automatic Identification System (AIS)
2.) Bathymetry
3.) Navigational Charts

4.) Waves
5.) Surface and subsurface currents
6.) Satellite imagery
7.) Ice distribution

Many of these observations are available in a common data format that can be self-describing, machine-independent and delivered through a web service. Examples of these observations are found within the Integrated Ocean Observing System (IOOS) which, for many gridded products, utilize a Network Common Data Format (NetCDF) for file structure and are distributed via a Thematic Real-time Environmental Distributed Data Service (THREDDS). The Open Geospatial Consortium (OGC) provides recommendations and examples of data formats and services for data sharing and delivery. These technologies are developed and have proven examples for in-situ time series data (e.g. AIS, temperature, wind speed, salinity); gridded data and model output (e.g. HF radar derived service currents, waves, ice coverage); and imagery feeds (e.g. remotely sensed ocean color, pictures, charts). The data can also be displayed via open source – online platforms such as OpenLayers and Google Earth for unclassified interfaces or desktop applications such as TOPSIDE emerging from the Naval Undersea Warfare Center (NUWC) as a result of ONR-sponsored MDA and surveillance programs.

A USCG example is the Search and Rescue Optimal Planning System (SAROPS). This is an ArcGIS 9.3 (soon to migrate to 10.1) application designed specifically for search and rescue. SAROPS is directly supported by the USCG Environmental Data Sever (EDS), which accesses environmental data and models, archives that data, and upon request from SAROPS, returns data cubes for the SAROPS trajectory predictions. The EDS gathers data from the HF Radar National Network (HFRNet) and short term prediction based upon HFR data. I will expand upon this system and its history in the section addressing HF radar. A separate, but compatible tool, could be designed for tracking submerged oil spills, monitoring fishing areas or maintaining vessel awareness. Our experience in operational data systems suggest that large-scale "system of systems" or "one-stop shops" inevitably fail due to volume, complexity, or monumental requirements that prevent the system from ever deploying. Light-weight, problem/user driven applications have been found to be much more effective, easy to use, flexible, and can be rapidly developed and tuned to user needs. Underlying data feeds, such as the EDS, that are common to all applications are easily reused and custom products for the specific problem can be developed and added. Modular, problem driven applications will be more cost effective, straightforward to use, and flexible.

Scripps recommends designing modular, problem driven applications that can be built upon the same technology, but are tailored to a specific application or problem area. This approach was taken when developing an online visualization for the pilots in Los Angeles/Long Beach harbor. The stakeholders were primarily interested in overlays of charts, waves, surface currents, and wind predictions. An online, interactive application was built to match their needs.

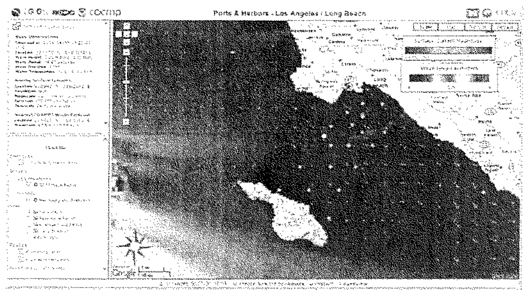


Figure 1. SCCOOS online ports/harbors custom interactive application

The Port of Los Angeles/Long Beach is an emerging example of the importance of timely and precise wave information. For background, maritime transportation plays a major role in Southern California's economy and national defense system. Combined, Los Angeles and Long Beach comprise the largest port in the U.S. and the fifth largest port in the world. The Port is presently seeing new classes of supertankers whose under-keel clearance can be limited when waves are too large. Precise measurement and forecasting of wave conditions and sea level is being explored to aide decision support tools for these tankers. The need for precise observations and forecasts exist throughout Southern California. The Port of San Diego includes the largest naval fleet in the world, and Port Hueneme is the only deep water port between Los Angeles and San Francisco and the only Navy controlled port between San Diego and the Puget Sound. The Santa Barbara Channel and San Pedro shelf are the locations of several active oil fields with sustained reserves, as well as major shipping channels.

The unique challenge for marine operations in Southern California is to assure that the vast amount of maritime traffic is provided with the highest quality ocean observations and models to assure safe and efficient transit as well as effective event response. The Integrated Ocean Observing System is addressing this challenge by partnering with institutions and agencies to provide data access and products for waves, surface currents, and winds, all critical parameters for safe maritime operations. The integration of the wave data on the NOAA PORTS site is now underway at four ports: Los Angeles/Long Beach, San Francisco, Mouth of the Columbia and the Chesapeake. This will serve as a template for further IOOS data integration and displays. In summary, the concerns raised by the July, 2013 GAO report are not insurmountable through adoption of common standards, building from existing data display and fusion systems, and partnering with organizations already invested in MDA.

3. Improving the Use and Integration of Maritime Domain Awareness Data: Emerging Technologies and Emerging Needs

High Frequency Radar (HFR):

High-frequency radar (HF radar) systems measure reflecting radio waves off the surface of the ocean. Each HF radar land-based installation is sited near the coastline and includes two antennas: the first transmits a radio signal out across the ocean's surface, and the second listens for the reflected radio signal after it has bounced off the ocean's waves. By measuring and processing the change in frequency of the radio signal that returns, known as the Doppler shift, the system determines how fast the water is moving toward or away from the antenna. Data from neighboring antennas are processed and displayed to the user as surface currents maps in near real-time.

A national HF radar network (HFRNet) has been established to measure surface currents throughout the U.S., and is currently supported by NOAA-IOOS and used in operational applications through delivery of products by the National Data Buoy Center (NDBC). Scripps developed and has operated data management for integration, distribution, and visualization of HFR surface currents for 10 years since the national network was initiated. The network includes approximately 31 participating organizations, with approximately 133 radars operating 24/7/365.

Beginning in 2000, the USCG Research and Development Center began a multi-year investigation into the utility of near real-time HF radar derived surface current measurements for search and rescue (SAR). This assessment showed a better comparison of radar-derived currents when compared against available NOAA tidal current predictions. Additionally a key element using the HF radar currents was the development of the Short Term Predictive System (STPS), a forecasting model that uses statistical information for surface current prediction. Following these evaluation studies, available in situ data were used to evaluate and define appropriate parameters for inclusions in the USCG search and planning tool as the inclusion of HF radar currents reduced the search area for USCG operators by two-thirds. Current velocities from HFRNet and the STPS forecasts are included in the USCG SAR Optimal Planning System. Data is made available in an easily digestible format through web services that were previously mentioned. This allows for integration in multiple applications and the data are used across an array of varying operational GIS based displays.

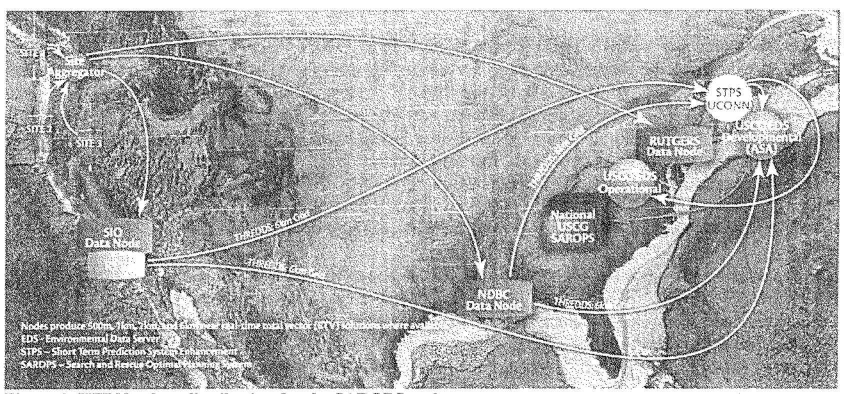


Figure 2. HFRNet data distribution for the SAROPS tool

Additional integrated operations that are cross-agency applications between USCG and NOAA include:

1. Oil Spill: Office of Response and Restoration (OR&R) Emergency Response Division (ERD) - Official NOAA forecasts for oil spill trajectories General NOAA Operational Modeling Environment (GNOME); National Preparedness Response Exercise Program (NPREP); CA Office of Spill Prevention and Response (OSPR)
2. Environmental Assessment: Office of Response and Restoration (OR&R) Assessment and Restoration Division (ARD) - Environmental Response Management Application (ERMA)

HF radar technology is also being developed for over-the-horizon ship tracking applications and is an emerging technology for maritime domain awareness. In 2008, the Department of Homeland Security established two DHS Science & Technology (S&T) Centers of Excellence (CoE) – the National Center

for Secure and Resilient Maritime Commerce (CSR) and the Center for Island, Maritime, and Extreme Environmental Security (CIMES). Their missions include basic research and education that develops and transitions new technologies supporting Maritime Domain Awareness (MDA) at three scales – the global scale observed via satellite, the approach scale observed by beyond-the-horizon HF radar, and the local scale observed via line-of-site microwave radars, cameras and underwater acoustics. The HF radar research focused on development of a dual-use surface current mapping and vessel-tracking capability. This capability is designed to bridge a surveillance gap between the low update rates provided by global satellite coverage and the high update rates of local line-of-sight microwave radars and underwater acoustic sensors in ports and harbors. The integration of the long range capabilities of HF radar and shorter range target detection provided by microwave systems was recently demonstrated for the first time independent of DHS as part of U.S. Navy exercises in the Pacific (Balikatan 2014) as a collaboration between Scripps, NAVAIR, and PACOM. The results of this test, and other tests previously conducted in the U.S. under Department of Homeland Security funding, suggest that the U.S. HF radar network operated for IOOS to map coastal currents could be operated in a manner to provide dual-use function for identifying ship traffic. However, this opportunity will remain elusive under the current funding model for this national asset as the network is funded only at 50% operational capability of the $10M/year build out plan as identified in the U.S. IOOS National Surface Current Mapping Plan.

Unmanned Vehicles:

Unmanned Underwater Vehicles (UUVs), also referred to as Autonomous Underwater Vehicles (AUVs) continue to develop as the frontier technology for subsurface exploration and sensing advances. Examples include buoyancy driven gliders, such as the SPRAY system developed by Scripps for wide area environmental surveillance and propeller powered vehicles such as the REMUS (Remote Environmental Monitoring UnitS), originally designed by the Woods Hole Oceanographic Institution (WHOI) and now available commercially from Hydroid Inc., for short duration, high-resolution surveys. Both vehicles can employ a variety of acoustic, optical, and physical sensors to analyze open ocean, littoral and benthic environments and can assist the USCG in detecting and tracking oil spills of unknown origin, finding sunken wrecks, mapping bathymetry and hazards, and detecting illegal fishing activities.

The role of UUVs in mapping the seafloor has received public attention in light of the Malaysian Air tragedy. UUVs are rapidly becoming 'underwater pickup trucks', and can precisely navigate at depths unreachable by divers and conduct surveys with a variety of surveillance sensors at speeds and efficiencies unattainable by other means. My team at Scripps has used smaller versions of the same system that found the Air France crash site to conduct surveys to map ecosystems and natural resources, map subsurface plumes, detect changes in bathymetry after typhoons, and search and identify missing aircraft and sunken ships. In conjunction with collaborators at the University of Delaware, we recently used UUVs equipped with sidescan sonar to find two missing planes from WWII and over a dozen unknown ships in the western Pacific Visualization of large data sets generated by UUVs has the capability to map habitats and show impacts from sunken buoys and anchor scours. Onboard sensors such as fluorometers can measure the presence of oil. Aggregation of imagery and sensor information can assist the USCG mission in determining the risk of oil leaks from submerged wrecks. With over 6000 ships from WWII believed to be resting on the seafloor, a significant amount of oil remains submerged aboard long-sunk vessels. The threat of oil leaks is increasing due to 70 years of corrosion.

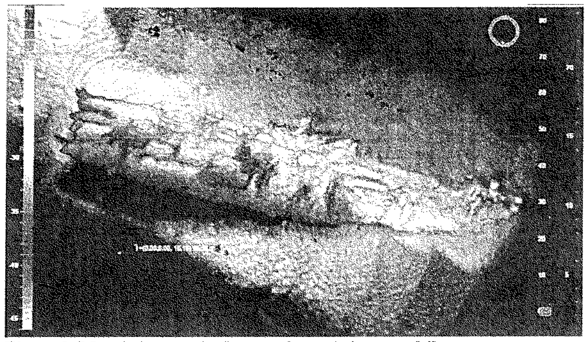


Figure 3. Mosaic image of submerged wreck from multibeam sonar

Another UUV are the buoyancy propelled underwater gliders were used in the 2010 Deepwater Horizon spill in the Gulf of Mexico for analyzing water column properties and detecting the presence of oil. Gliders narrowed the search zone for subsurface oil and provided valuable information to constrain ocean forecast models that were being used to predict where the oil might be transported. Through IOOS, the glider community is establishing a common data format for glider near real-time data feeds. This will significantly improve the ingestion and display of glider data retrieved from varying platform vendors. Ocean gliders have proved invaluable in providing persistent underwater surveillance of changing ocean conditions for purposes of tracking changing climate signals including El Nino. The data are used by operational forecast models operated by NOAA and the Navy, and is an excellent example of technology developed by the Navy transitioning to other agencies within the U.S. Government. NOAA and its IOOS partners have recently drafted a National Network Glider Plan to provide an implementation roadmap to serve U.S. needs to monitor the subsurface ocean. Implementation of the plan is recommended so that U.S. has the capability to understand and forecast changing ocean conditions for fisheries and coastal weather predictions.

Another use of glider technologies that is worth mentioning is the modernization of the Tropical Ocean and Atmosphere Observing (TAO) system. The TAO system has proved highly valuable for improving understanding and forecasting of El Nino/Southern Oscillation (ENSO) variability, including its impacts on North American rainfall and temperature. The ENSO cycle is operationally relevant to USCG and first responder interests as typically the larger and stronger winter storms occur during the El Nino phase of the ENSO cycle, with coastal erosion and coastal flooding typically the norm. As it becomes increasingly difficult to sustain the conventional observations initiated in the 1980s that provide us El Nino forecast capabilities, new observational technologies are being examined to enhance the effectiveness and efficiency of the ENSO observing system. A nascent project has begun that will augment the equatorial Pacific distribution of Argo floats, demonstrate the use of glider technology as an alternative to subsurface moorings, and evaluate the impact of these novel approaches in combination with other related satellite and in situ observations. The goal is to demonstrate how this suite observation technologies will improve our knowledge of the evolving physical state of the tropical Pacific Ocean, as well as provide an improved equatorial Pacific dataset for researchers and for operational ocean state and forecasting centers around the world.

Education/Training:

Scripps-UCSD is well positioned to serve the Nation's maritime security needs by educating the next generation technical workforce. It is well recognized that the country's capability to remain competitive on a global scale is tied to our success in stimulating interest in Science, Technology, Engineering, and Mathematics (STEM) fields. For the maritime sector, Scripps presently plays an educational role at the MS and PhD programs, especially through the Applied Ocean Sciences (AOS) program. For example, a recent USCG masters graduate of the program went on teach at the USCG Academy and is now at Office of Science and Technology Policy, Executive Office of the President. Another active-duty naval officer who obtained his Ph.D. at Scripps was recently nominated for appointment to the rank of rear admiral and will become the next Commander of the Naval Meteorology and Oceanography Command.

Additionally, grants provide partnerships for education and training. Through the National Science Foundation's (NSF) program Ship-based Science Technical Support in the Arctic (STARC), Scripps provides marine science and technical services to NSF-supported research cruises aboard the U.S. Coast Guard cutters HEALY and POLAR SEA. This program is a collaborative between the Shipboard Technical Support (STS) department at Scripps and the Marine Technician Group (MTG) at Oregon State University (OSU) that provides the highest level of shipboard technical support possible. The program uses a model for Arctic shipboard technical support that follows best practices of the University-National Oceanographic Laboratory System (UNOLS) fleet.

Education and training of students, new technicians and USCG personnel in use of technology and techniques at sea are among the broader impacts of this effort, thus growing the technical knowledge base that supports U.S. oceanographic research. Scripps supports the acquisition and appropriate handling of underway shipboard data in concert with national data centers such as the NSF-supported Rolling Deck to Repository (R2R) program, making data available to the academic community and the public at large. Scripps and OSU will coordinate with NSF, USCG and the Arctic Icebreaker Coordinating Committee to define priorities for maintenance and upgrades to science equipment onboard.

4. Closing and Recommendations

In closing, I would like to thank the Committee for the opportunity to testify on the role of ocean technologies and provide suggestions for the U.S. to leverage on-going investments to promote and improve maritime domain awareness. Scripps' scientists are leaders in research and operational use of maritime technologies and have a long history with national defense-related science, and as an organization, we are privileged to be positioned to provide national service to this increasingly important topic. I believe that development of partnerships between USGS and other agencies (e.g. ONR, NAVAIR, DARPA) for purposes of pursuing defense-related observational strategies and then testing those strategies through demonstrations is very important. The west-coast is well poised to support these demonstrations. In addition to recommending stronger partnerships between the USCG and the DOD research enterprise, it is recommended that the Integrated Coastal and Ocean Observation System Act of 2009 be reauthorized. This Act has been introduced in the House and is awaiting Senate approval. This legislation authorizes IOOS and provides the interagency framework to guide the nation's strategy to sense the ocean, and connect ocean data across Federal/non-federal partnerships. NOAA-IOOS directly supports USCG missions for Search and Rescue and Oil Spill Response and reauthorization of ICOOS would continue to foster NOAA-USCG partnerships. Scripps recommends full funding for the U.S. National Surface Current Mapping Plan to provide national uniformity in the benefits of the network including search and rescue and oil spill response. The funding for this Plan has remained flat funded at the 50% operational capability level since being established as a NOAA budget line three years ago. Funding of the IOOS national glider plan is another logical step once it has been completely vetted by the user community.

Subcommittee on Coast Guard and Maritime Transportation

Hearing on Using New Ocean Technologies: Promoting Efficient Maritime Transportation and Improving Maritime Domain Awareness and Response Capability

Wednesday, May 21, 2014

Questions for the Record from Congressman John Garamendi

National Research Council 2011 Ocean Infrastructure Recommendations

In 2011, the Ocean Studies Board of the National Research Council released a report entitled, Critical Infrastructure for Ocean Research and Societal Needs in 2030. This forward-thinking report recognized that a coordinated national plan for making strategic investments in ocean infrastructure was necessary to maintain fundamental ocean science research over the next twenty years.

Furthermore, the report stated that a growing suite of infrastructure will be needed to address urgent societal issues, including tsunami detection, climate change, and offshore energy development and fisheries management. The report also offered several recommendations, notably the need to support continued innovation in ocean infrastructure development, and to engage allied disciplines and diverse fields to leverage technological developments outside oceanography.

- ***To your knowledge, have Federal agencies embraced the recommendations made by the Ocean Studies Board? Has the effort been made to develop a coordinated national ocean infrastructure plan to help guide the private sector and ocean research community on where they should best focus their energies?***

ANSWER: In the report, the Ocean Studies Board (OSB) identified some important infrastructure needs for the future, including: 1) maintaining access to the research fleet; and 2) using satellite observations data, global arrays of unattended environmental sensors, and autonomous platforms to support sustained ocean observations. However, the Office of Science and Technology Policy (OSTP) may be better equipped to address how well Federal agencies have embraced the recommendations made by OSB, and if an effort has been made to develop a coordinated national ocean infrastructure plan to help guide the private sector and ocean research community. New research vessels and refurbishment of the Alvin submersible are examples of federally funded infrastructure improvements for the science community.

- ***Does this plan generally align well with the most important scientific questions and priorities of the ocean science and research communities?***

ANSWER: The needs and priorities of the ocean science and research communities are diverse; however, as I mentioned above, the study identified some important technology needs that can support both ocean science priorities as well as our national security needs.

- ***In general, does this type of plan, one that identifies priorities and investment strategies for Federal agencies, help or hinder private sector firms? Can it function as a constraint on science and technology innovation?***

ANSWER: Long range plans are good, but they require updating. Additionally, in an economy of diminishing resources, funding plans based on long-term strategies can slow the evolution of "leap ahead" innovative technologies not envisioned at the time of the drafting of a long range plan. Building in opportunities to reassess long range goals and incorporate new technologies is important. Continual funding opportunities for rapid innovation are key.

National Integrated Ocean Observation System

In 2009, building on the initiative of the ocean science community, the Congress passed legislation providing an organic authority for the establishment, administration and operation of a National Integrated Ocean Observation System, or IOOS. Since then, IOOS has continued to mature and expand its monitoring, observation and data sharing capabilities. Most important, IOOS has more than demonstrated its versatility and value providing information vital to Federal responses to recent disasters, including Hurricane Sandy and the DEEPWATER HORIZON oil spill, and to improving the accuracy and efficiency of Coast Guard Search and Rescue operations. Most witnesses at the hearing spoke positively about the multiple benefits now available through investments made in IOOS infrastructure.

- ***In your opinion, how can we best support IOOS to ensure the continued build out and expansion of the planned IOOS architecture, and the further integration of IOOS data into basic and applied ocean science research?***

ANSWER: IOOS has demonstrated capability during times of national need, yet has faced stagnant funding. Increased funding for IOOS could help fill critical gaps in the observing system and improve modeling and predictive capacity, which is needed for both basic and applied research. Support for both the regional observing systems that deploy these systems, as well as operation and maintenance costs is critical to the continued build out of the program. According to the Congressionally-mandated Independent Cost Estimate (ICE) conducted by the Jet Propulsion Laboratory Science and Technology Directorate in 2012, a fully developed federal and regional system, which includes weather and ocean satellites, would cost $54 billion. Since an investment at this level appears unlikely, IOOS could benefit from leveraging other scientific resources, and from targeted build out plans. For example, fully funding the U.S. National Surface Current Mapping Plan would provide national uniformity while improving navigation, search and rescue efforts, and oil spill response. Funding the IOOS National Underwater Glider Network Plan is another logical step once it has been completely vetted by the user community. The Glider Plan proposes to link coastal systems to the deep ocean through sustained and cost effective spatial in situ sampling. This sampling, when combined with rapid response, could further support efforts like ecosystem forecasting, hurricane prediction, and water quality forecasting.

Additionally, the Integrated Coastal and Ocean Observation System (ICOOS) Act of 2009 should be reauthorized. This Act has been introduced in the House and is awaiting introduction in the Senate. Currently, the House proposed reauthorization (H.R. 2219) would reduce current funding for the program, and could result in the removal of infrastructure in the water, reduced management and modeling capacities, and the loss of trained technicians. Reauthorization of the ICOOS Act at higher levels will ensure that IOOS continues to address critical coastal issues such as safe navigation, search and rescue, and hazards such as extreme storms and oil spills. It would also provide a strong foundation for the program, and enable interagency coordination and collaboration with regional partners in both the public and private sectors.

- ***How can we best ensure that the private sector is able to continue to develop innovative products and services derived from observation data gathered by IOOS infrastructure?***

ANSWER: Open and easy access to the data generated by IOOS, which is a hallmark of the program, will ensure that the private sector can continue to develop value-added products and services based on its observational data. Once IOOS is able to provide national coverage, and its data management needs are sufficiently funded, the private sector will be able to better capitalize on IOOS data just as private weather companies have been able to leverage data provided by NOAA.

- ***Have the eleven certified IOOS regional associations performed as expected? If not, what recommendations might you provide to enhance the capabilities of the regional associations?***

ANSWER: The Regional Associations (RAs) serve the valuable role of connecting local user networks to the data and products provided by IOOS. They have transformed from a system of individual programs to a national network that provides high resolution information to federal agencies and regional entities to address the range of needs. Their persistence in the program serves as testament to the vested interest that the RAs have in the success of IOOS.

Although none of the RAs are currently certified, NOAA published certification rules for the RAs in May 2014, and each of the 11 are preparing to undergo the certification process. To better capitalize on the long-term build out plans that each of the RAs have developed to address stakeholder needs and priorities, capabilities could be enhanced by: 1) establishing commonality in the types of regional observational capabilities supported by the federal government; 2) increasing funding for existing observations to bring them to an initial operating capability prior to starting new programs, to allow for the needed repair of aging infrastructure, and to fill critical observation gaps; and 3) increasing funding for data management and product development to allow for the interoperability of the nation's observational systems and increased usage of the IOOS data and forecasts.

- ***To your knowledge, has any analysis been completed to determine the level of economic activity leveraged by Federal and non-Federal investments in IOOS infrastructure? Should authorized funding levels for IOOS be increased?***

ANSWER: The IOOS Program Office is currently studying the private sector's involvement in IOOS, and the resulting report should provide better estimates of the economic activity leveraged by investments in IOOS. However, earlier studies estimated a return on investment of 5:1 for Regional IOOS, which was based on the use of IOOS data to save lives (thanks to improved search and rescue efforts), improved commercial navigation, and early harmful algal bloom outbreak warnings for shellfish growers and harvesters, among other measures.

As mentioned above, the House proposed ICOOS reauthorization (H.R. 2219) would reduce current funding for IOOS, and could result in the removal of infrastructure in the water, reduced management and modeling capacities, and the loss of trained technicians. Authorized funding levels for IOOS should be increased to ensure that the program can continue to address critical coastal issues such as safe navigation, search and rescue, and hazards such as extreme storms and oil spills.

<u>Need to Maintain STEM Funding</u>

As I mentioned in my opening remarks at the hearing, the United States remains the world's leader in science but its preeminence is now being challenged aggressively by international competitors, notably China and India. Some people believe that this circumstance is directly related to insufficient funds being invested to support STEM education in the United States.

- ***From the standpoint of marine engineering and technology development, how important is it for the United States to maintain its investments in STEM education?***

<u>ANSWER</u>: Investments in STEM related to maritime technology are paramount to U.S. national security. U.S. innovation in the maritime sector is quickly being out-paced by foreign countries. By better integrating STEM at the kindergarten through graduate levels, the U.S. will be able to better meet its marine technology needs in the future.

- ***Is it practical to believe that the United States will be able to maintain its competitive edge against other global competitors if we fail to invest sufficiently in STEM education?***

<u>ANSWER</u>: No. To maintain the U.S.'s competitive edge, we need to sufficiently invest in STEM education.

- ***Regarding maritime education, how important is it for the Congress to continue to provide financial support for the U.S. Merchant Marine Academy and the six state maritime academies? Is the type of maritime training made available through these institutions a necessity for future ocean science and research?***

<u>ANSWER</u>: Congressional support for Merchant Marine should be expanded to include the higher education institutions that support the training of students in marine technology and ocean sciences. While there is a healthy and predictable career path for merchant academy graduates into maritime commerce, the future is much less certain for graduates in the field of marine technology and ocean science. STEM funding can help motivate the next generation technical workforce, improve the health of our economy, and retain our capability to compete globally. The U.S. is not keeping pace globally in attracting and providing education to students in STEM fields. National initiatives to address these deficiencies, including the America COMPETES Act (P.L. 100-69 signed into law on August 9, 2007), are important for addressing insufficient investments in today's STEM education and workforce development. STEM is inextricably linked to national security and programs to address future workforce needs of the Department of Defense need to continue.

The Navy in particular has unique needs for its STEM workforce due to the emerging reliance on unmanned underwater systems. Currently, the Navy has relatively few commercial applications for underwater technology, as opposed to ground or airborne systems that leverage civil and commercial applications. Naval doctrine, as outlined in the 2004 Navy Unmanned Undersea Vehicle (UUV) Master Plan, calls for a suite of four different classes of vehicles to address a wide range of naval operations including Intelligence, Surveillance, and Reconnaissance; Mine Countermeasures; Anti-Submarine Warfare; Inspection / Identification; Oceanography; Communication / Navigation Network Node; Payload Delivery; Information Operations; and

Time Critical Strike. Increasing reliance on autonomy and the collective behavior of systems (e.g., see Defense Studies Board, The Role of Autonomy in DoD Systems, 2012) further demands shaping of the future workforce in specialty disciplines that support unmanned undersea platforms and their sensors. Example technical challenges of unmanned platforms, as outlined in various Office of Naval Research symposia, include the ability to operate near shore, improving operators' skills at running unmanned systems, communications connectivity, handling and increasing number of complex missions, power systems, onboard sensing, and the ability to operate in real time. Challenges remain for stimulating the next-generation workforce entering the field of underwater robotics, unmanned systems, and sensor technologies. Well-defined career paths to support U.S. needs for ocean technology need to be identified, and public-private partnerships are the key to addressing these challenges.

Recommendations for Better Coordination between Public/Private Sectors

In general, ocean science research and engineering has been predominantly a collaborative enterprise between a select few Federal agencies, notably the U.S. Navy, the National Science Foundation, and the National Oceanic and Atmospheric Administration, with universities and private sector contractors. And while this model has produced substantial scientific achievements, I get the sense that more could be done to improve coordination, to better leverage Federal investments, to address emerging ocean science objectives, and to provide new markets for ocean technologies.

- ***What recommendations can you offer to improve the coordination of Federal agencies, both among themselves and with their extramural partners in the private sector and university community?***

ANSWER: As I mentioned in my written testimony, there is value in establishing and carrying out technology demonstrations with the participation of other agencies. For example, there are USCG and Office of Naval Research partnerships that exist for research programs in the Arctic; and operational partnerships exist in the Joint-Interagency Task Forces (e.g. JIATF-S, JIATFW) for combatting illegal drug trade on the high seas. Improvements to linking the U.S. Coast Guard Research and Development (R&D) Center with the Office of Naval Research would promote transitions in technologies and training that are being developed to address the challenges of maritime domain awareness (MDA) including monitoring vessel traffic. Defining and funding demonstration efforts to tackle these challenges would be considered a logical next step. The National Ocean Partnership Program (NOPP) is another intergovernmental funding program for research that partners federal agencies with the research community. NOPP funding has decreased in recent years.

The Navy's Defense University Research Instrumentation Program (DURIP) funds the purchase and development of research equipment and infrastructure by academic institutions through a competitive grant process managed by the Office of Naval Research, and is an example of a program that helps improve agency-university coordination. This instrumentation plays a vital role in allowing defense-critical research projects acquire needed technical resources specifically engineered to meet their requirements. Past DURIP funded projects have enabled scientists and engineers to develop and deploy oceanographic acoustic and radar technologies, advancing our understanding of acute changes in the ocean environment that are necessary to inform battlespace tactics. DURIP program benefits also include cost-effective testing of new equipment in the rigors of the ocean in order to fully develop identification and recovery methods prior to actual federal agency field operations. Continued funding for programs like DURIP will help

improve agency-university coordination while advancing ocean science objectives, and better meeting the country's national security needs.

- ***What can be done to improve the Coast Guard's interaction and collaboration with the ocean research and Blue Tech communities to address the Coast Guard's operational mission needs?***

ANSWER: Coast Guard research and development (R&D) needs significant funding and stronger partnerships with other agencies that share like missions (e.g. Dept of Defense) so it can better capitalize on the work of our nation's blue tech communities.

- ***Should the Coast Guard work more closely with the Office of Naval Research or Oceanographer of the Navy in areas of common interest, particularly in the littorals?***

ANSWER: Yes. The U.S. Coast Guard R&D Center requested assistance from the Office of Naval Research (ONR) over a year ago to host a workshop to share with USCG details on emerging naval systems that might be relevant to addressing the challenges of maritime domain awareness (MDA). The workshop included a broad range of subject matter experts and one outcome from the meeting was the identification of various concepts of operation for different MDA challenges facing the USCG. Defining demonstration efforts to tackle these challenges as follow-on to the workshop, and more importantly, resourcing the R&D Center to partner with other appropriate S&T organizations such as ONR should be considered a logical next step.

A stronger partnership between USCG and ONR could translate to more effective transition capabilities, and more efficient testing of defense related observational strategies. Demonstrations are one avenue for testing those strategies. USCG mission requirements for MDA are only increasing as a result of growing responsibilities that U.S. has with partnership countries in the Pacific (e.g. Federated States of Micronesia, Republic of Palau) as well as the U.S. management of the Papahānaumokuākea Marine National Monument. With a stronger USCG-ONR relationship, both agencies' missions could be better supported. The development of U.S. capabilities for MDA to support Pacific operations were underscored at the recent Department of State "Our Ocean" conference in which the difficulties of surveilling large regions of the ocean for illegal fishing were emphasized.

UUV and UAV Security

Underwater Unmanned Vehicles (UUVs) and Underwater Autonomous Vehicles (UAVs) are assuming a greater role as a tool for ocean research. Additionally, greater attention is now being devoted to investigating the potential use of UUVs and UAVs for other purposes, including for Maritime Domain Awareness. Some questions have come up concerning the both the cybersecurity and physical security of these assets once deployed in the marine environment, especially whether these assets might be co-opted, confiscated or otherwise compromised by our enemies.

- ***What are your views on the security profile of UUVs and UAVs in the marine environment? What can be done to prevent hackers from accessing and controlling these vehicles?***

ANSWER: Distinctions should be made between unmanned systems collecting environmental data, and those systems for security/MDA purposes. For cybersecurity issues, systems used for security related efforts should adhere to an information assurance plan. Information assurance is a well-defined process and Office Naval Research as the sponsoring R&D organization at the forefront of unmanned systems, should be considered a resource for further information. Physical security of unmanned assets is most related to damage from vessel strikes. Mission planning and piloting of systems outside of regions of vessel traffic are becoming best practices for the communities which operate these systems.

- ***What type of risk does this create for ocean science researchers or other maritime operators whose dependence on these assets for data gathering, communication, surveillance and other activities is projected to grow dramatically in the future?***

ANSWER: This problem has not been well studied for the broader marine science community.